4/1/74

# GEOLOGY

Part of a Study the California Coastal Zone

Summary of the report: "Coastal Geology and Geological Hazards", compiled by State and Regional Coastal Zone Commission staff, with extensive assistance from Ms. Elene Johnston and Mr. William Adent. Regional information was prepared in cooperation with Dr. Ken Lajoie and Dr. Gary Greene of the U.S. Geologic Survey, Menlo Park.

The California Coastal Zone Conservation Act of 1972, (Proposition 20 at the election of November 7, 1972) created the California Coastal Zone Conservation Commission and six Regional Commissions, and directed them to prepare a comprehensive, enforceable plan for the preservation, protection, restoration, and enhancement of the coastal zone.

This is one of a series of informational reports designed to help the Central Coast Regional Commission carry out this responsibility. Using these reports, the Regional Commission will develop recommendations to the California Coastal Zone Conservation Commission on statewide policy to this Region. These recommendations, together with the recommendations of the other five Regional Commissions, will be the basic materials the State Commission will use in planning the plan for the future of the California coast.

Each report focuses on a specific aspect of the Coastal Zone. The relationship of this report to others in the series may be seen at a glance on the next page.

This summary report was prepared by the Commission staff to focus on the most important Coastal planning considerations suggested by the more extensive technical report. Possible planning recommendations based on this report are listed at the end. These are only tentative, since the conclusions based on this report will need to be considered later, after other reports on different aspects of the Coastal Zone have been completed.

Cover Photo: Jack McDowell

CENTRAL COAST REGIONAL COMMISSION

SANTA CRUZ

April 1, 1974

# PREFACE

This report is the second of nine elements of the Coastal Plan covering the following subjects:

1. Marine Environment
2. Geology
3. Coastal Land
4. Appearance and Design
5. Recreation
6. Energy
7. Transportation
8. Intensity of Development
9. Powers, Funding and Governmental Organization

The Central Coast Regional Commission is responsible for planning the coastal region of San Mateo, Santa Cruz and Monterey Counties. In order to encourage public participation, the Commission will hold public meetings to discuss the implications of this report at:

Monterey Peninsula College
Monterey County
Social Science 102
Friday - April 19, 1974
7:30 p.m.

Skyline College
San Mateo County
Building 2, Room 308
Friday - April 26, 1974
7:30 p.m.

Board of Supervisors Chambers
Santa Cruz County Governmental Center
Monday - May 6, 1974 (Formal Public Hearing)
7:30 p.m.

This summary is abstracted from an extensive technical report covering statewide and regional issues. Copies of the technical report are available for review at the Commission office or at the following public and school libraries:

San Jose State University
Main Library
125 - 7th Street
San Jose, California 95112

Cabrillo College
Library
6500 Soquel Drive
Aptos, California

Hartnell College
Library
156 Homestead Avenue
Salinas, California

San Mateo County Library
Central Branch
25 Tower Road
Belmont, California

Santa Cruz Public Library
Main Branch
224 Church Street

Half Moon Bay Branch
Public Library
620 Correas Avenue
Half Moon Bay, California

Emerson Branch Library
Elm Avenue & Imperial
Seaside, California

Daly City Public Library
Westlake Main Branch
275 Southgate Avenue
Daly City, California

Harrison Memorial Public Library
Ocean Avenue & Lincoln
Carmel, California

University of California
Santa Cruz
Library
Santa Cruz, California

Monterey Peninsula College
Library
980 Fremont
Monterey, California

Skyline College
Library
3300 College Drive
San Bruno, California

Monterey City Library
Madison & Pacific Streets
Monterey, California

Monterey County Public Library
26 Central Avenue
Salinas, California

Pacific Grove Library
Central Avenue & Fountain Avenue
Pacific Grove, California

Watsonville Public Library
310 Union
Watsonville, California

Pacifica Branch Public Library
Hilton Way & Palmetto Avenue
Pacifica, California

See last page of this summary to obtain a copy of the technical report.

- Shattered windows, cracked walls, and debris covered roads after a quake -
- Houses slipping hopelessly down a slope on a mud slide -
- Whole sections of a coastal city battered by massive sea waves -
- A favorite beach stripped of its sand, perhaps dumping a nearby house into the ocean -

* * * * * *

Earthquakes, landslides, tsunamis (earthquake-born sea waves) and shoreline erosion - these are the four major geologic hazards of California's Coastal Zone.

Most Californians have seen, or even experienced, the effects of these dramatic natural forces. While these forces are largely unpreventable, and are essential steps in the constant geologic evolution of the earth, they need not exact extensive cost in lives, injuries, and property damage. As more and more is learned about these geologic processes, homes, roads, office buildings and other construction in our urban civilization can be located in safer places, and be constructed in order to withstand these natural forces.

With wise planning, major coastal geological hazards can be dealt with in a way which will enable people to continue to enjoy working, living, and visiting along the beautiful California coast.

<u>Earthquakes</u>

California is earthquake country. Earthquake shaking is the most widely experienced of all the State's geologic hazards. Most of the time it does little damage because the vast majority of earthquakes are small. In fact, California experiences literally thousands of earthquakes every year, but most are too small to notice or cause any noticeable damage.

The most noticeable effect of small earthquakes is "creep" along faults in the earth's crust, the best known of which is the San Andreas. The periodic slow movement or "creep" is thought to relieve tensions within the earth that might otherwise build up as huge blocks of the crust move in opposite directions to one another. Creep may gradually bend and damage structures that lie across the fault line.

Large damage from earthquakes occurs when movement along a fault is sudden, rocking buildings on the fault itself, shaking surrounding areas, triggering landslides on unstable slopes, and even liquefying certain wet soils.

Earthquake damage varies according to the intensity and duration of the shock, the type of soil affected, and how close cities are to the earthquake center (epicenter). The last large California earthquakes struck the San Fernando Valley in Southern California in 1971, with 58 people killed and much damage; a more recent earthquake hit Pt. Mugu in February 1973 with relatively little damage. The California Division of Mines and Geology estimates that earthquake shaking damage will reach $21 billion throughout the State of California between 1970 and 2000.

Earthquakes are particularly damaging in the coastal zone because of the large population centers along the coast. Both San Francisco and Los Angeles are located near the San Andreas Fault, and many other offshoot or "splinter" faults are near coastal cities. But the hazard varies from region to region along the California coast and its islands.

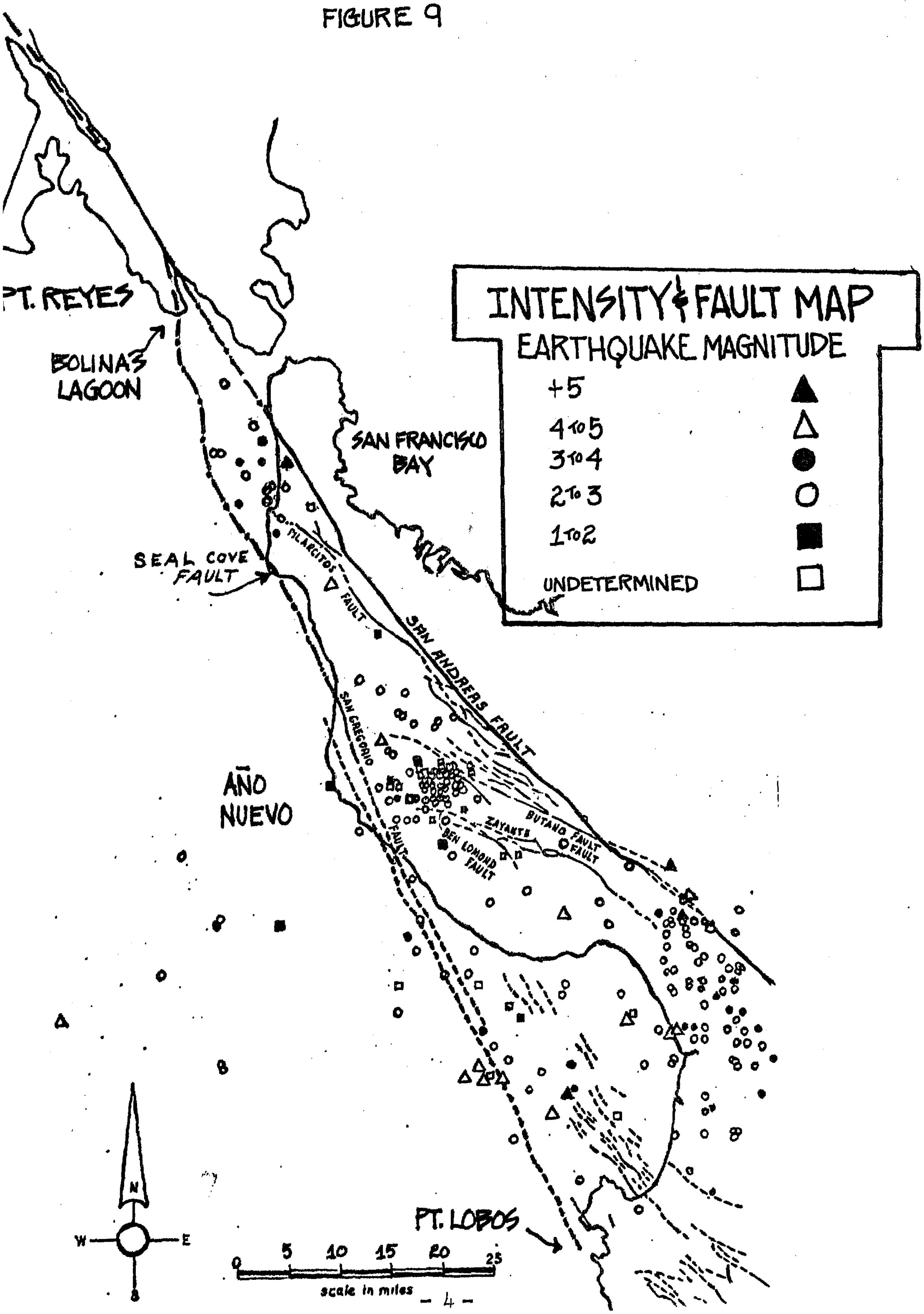
California recorded history of earthquakes is too short (barely 150 years) and spotty to give a complete picture of the earthquake threat along the coast. Accurate equipment to measure the quakes' location and intensity is still being refined, and mapping continues in large areas of California thought to be earthquake prone. This research and mapping should be encouraged if California is to understand and cope with the earthquakes and their effects.

The Alquist-Priolo Geologic Hazards Zones Act passed in 1972 calls for extensive mapping and research of known and potentially active fault areas. As this Act is implemented, earthquake risks in certain areas will be better known and development can be guided accordingly. For example, if a valley is known to have several earthquake faults, it might be safe to use the land for farming, but not for building a new factory.

The Joint Committee on Seismic Safety of the California Legislature in 1972 recommended the strict enforcement throughout the State of the Uniform Building Code to avoid shoddy construction and engineering techniques. The Joint Committee also recommended expanding the Alquist-Priolo Geologic Hazards Zones Act of 1972 to include all geologic hazards beyond just earthquakes.

As the Joint Committee indicated there must be continued mapping of fault zones and research into causes and prediction of earthquakes, and also specific examination of pieces of land before development begins.

FIGURE 9


INTENSITY & FAULT MAP
EARTHQUAKE MAGNITUDE
+5
4 to 5
3 to 4
2 to 3
1 to 2
UNDETERMINED
PT. REYES
BOLINAS LAGOON
SAN FRANCISCO BAY
SEAL COVE FAULT
PILARCITOS FAULT
SAN ANDREAS FAULT
SAN GREGORIO FAULT
AÑO NUEVO
BUTANO FAULT
ZAYANTE FAULT
BEN LOMOND FAULT
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0
5
10
15
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scale in miles

CENTRAL COAST REGIONAL SUPPLEMENT

Faults:

The San Andreas fault system is one of the largest and most seismically active structures in the earth's crust. The Central Coastal Region is transected at its northern extremity by the San Andreas fault zone itself and by one of its main branches, the Seal Cove - San Gregorio - Palo Colorado fault zone, throughout much of the region. The San Andreas fault crosses the Central Coastal Zone in Daly City and lies within 15 miles of the coastline north of Salinas and within 40 miles of the coastline from Salinas to the Monterey - San Luis Obispo County line. Because of its close proximity and potential for generating large damaging earthquakes, the San Andreas fault presents the source of seismic hazard in the Central Coastal Zone.

The Seal Cove - San Gregorio - Palo Colorado fault zone branches off the San Andreas fault at Bolinas Lagoon in Marin County and extends over 100 miles southeastward to the vicinity of the Monterey Peninsula (Figure 9). Recent minor seismicity, young geomorphic fault features, offsets of geologically young sedimentary deposits, and close relationship to the San Andreas fault indicate that this is an active fault zone. The length of this fault zone and its activity suggest that earthquakes as large as magnitude $7 \pm 0.5$ can be expected from movements along this fault zone (Green, et. al, 1973).

Between Bolinas Lagoon and Moss Beach in northern San Mateo County this fault zone lies offshore and was mapped by acoustic profiling from a ship. Between Montara and Princeton at the north end of Half Moon Bay the fault zone lies onshore and is expressed by a main strand called the Seal Cove fault, which runs along the base of the high linear ridge called the Seal Cove Bluffs west of the Half Moon Bay Airport, and several minor strands to the east. Vertical displacement of up to 150 feet on the Seal Cove fault has offset the lowest and youngest emergent marine terrace in the region (the Half Moon Bay terrace which is most likely 70,000 to 120,000 years old) and elevated the block west of the fault to form the Seal Cove Bluffs. The linear northeastern face of the Seal Cove Bluffs is therefore a fault scarp. Displacements on secondary fault strands east of the Seal Cove fault have offset several emergent marine terraces. Displacement on one secondary strand which runs through a brussels sprout field east of the Half Moon Bay Airport has offset a recent alluvial fan (less than 5,000 years old) and formed a westward facing scarp up to four feet high.

Between Princeton and San Gregorio, 13 miles to the southeast, the Seal Cove - San Gregorio - Palo Colorado fault zone again lies offshore. The fault zone is expressed as a series of linear ridges on the ocean floor across the mouth of Half Moon Bay but its location is not precisely known between Miramontes Point and San Gregorio.

Between San Gregorio and Point Ano Nuevo, 17 miles to the southeast, the fault zone lies onshore and is expressed as a broad complex zone of bedrock displacements, sag ponds, and linear ridges and valleys. The Ano Nuevo terrace, the lowest and youngest marine terrace in this area, (most likely between 70,000 and 120,000 years old) is offset and tilted by displacements along several fault strands. Alluvial deposits about 10,000 years old have been offset by displacement on a fault strand near the mouth of Ano Nuevo Creek.

Between Ano Nuevo Point and the vicinity of the Monterey Peninsula, the fault zone lies offshore and was mapped by acoustic profiling from ship-mounted equipment (Green, et. al., 1973). Displacements on fault strands in this area have offset marine deposits less than 5,000 years old and formed linear scarps on the ocean floor.

South of the Monterey Peninsula the fault zone comes ashore and is represented by the Palo Colorado fault which was mapped primarily on the basis of bedrock discontinuities.

In addition to the main coastal fault, the Seal Cove - San Gregorio - Palo Colorado fault zone, there are several other faults which show evidence of fairly recent geologic activity. Displacement on the Pilarcitos fault which branches off the San Andreas fault near Palo Alto has offset the lowest marine terrace (probably 70,000 to 120,000 years old) north of Pedro Point. Displacement on several fault strands in the broad Monterey Bay fault zone, which runs diagonally across the floor of Monterey Bay, offset marine deposits less than 5,000 years old and have formed scarps on the ocean floor (Green, et. al., 1973). Southeastward extensions of some of these fault strands offset young marine terrace deposits (70,000 to 120,000 years old) east of the Monterey Peninsula.

Seismicity:

The San Francisco Bay region is one of moderately high seismicity, largely associated with the San Andreas fault. Three major earthquakes related to this fault have resulted in damage or potentially damaging intensities on the coast between San Francisco and Santa Cruz. Only one earthquake on the Hayward fault (in 1868) has similarly affected the coast (Eppley, 1966). Seismicity on the San Andreas fault on the San Francisco Peninsula takes the form of infrequent large and small earthquakes, with apparently almost no intermediate shocks (exception is the Daly City shock, M=5.7, of 1957).

Small earthquakes and microseisms during the past 30 years were generally restricted to the San Andreas fault south of State Highway 152 between Gilroy and Watsonville but many occurred along faults throughout a broad area along the entire coastal zone (Figure 9).

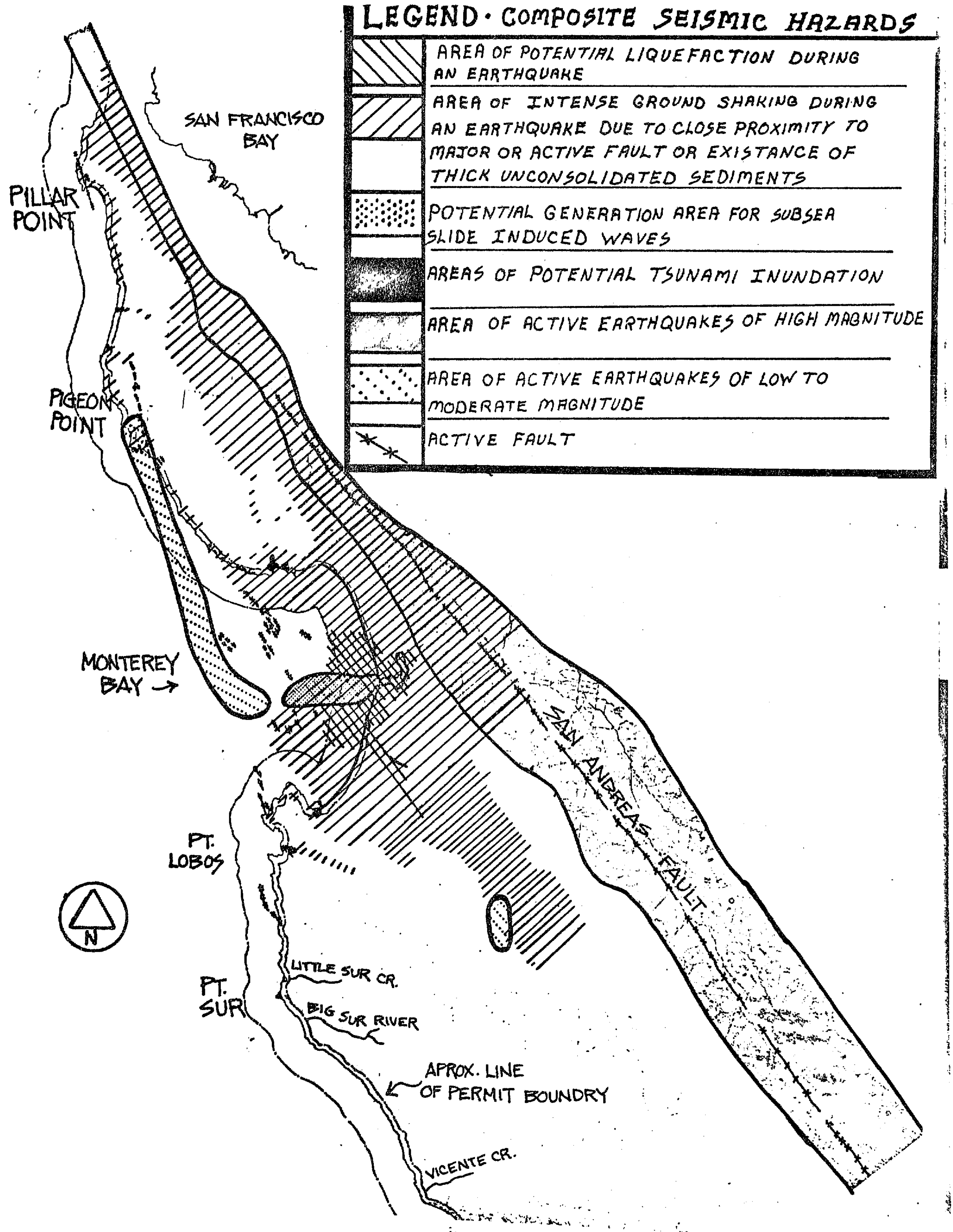

LEGEND · COMPOSITE SEISMIC HAZARDS
AREA OF POTENTIAL LIQUEFACTION DURING AN EARTHQUAKE
AREA OF INTENSE GROUND SHAKING DURING AN EARTHQUAKE DUE TO CLOSE PROXIMITY TO MAJOR OR ACTIVE FAULT OR EXISTANCE OF THICK UNCONSOLIDATED SEDIMENTS
POTENTIAL GENERATION AREA FOR SUBSEA SLIDE INDUCED WAVES
AREAS OF POTENTIAL TSUNAMI INUNDATION
AREA OF ACTIVE EARTHQUAKES OF HIGH MAGNITUDE
AREA OF ACTIVE EARTHQUAKES OF LOW TO MODERATE MAGNITUDE
ACTIVE FAULT
SAN FRANCISCO BAY
PILLAR POINT
PIGEON POINT
MONTEREY BAY
SAN ANDREAS FAULT
PT. LOBOS
N
LITTLE SUR CR.
PT. SUR
BIG SUR RIVER
APROX. LINE OF PERMIT BOUNDRY
VICENTE CR.

FIGURE "A"

Towns on the east side of the Peninsula were severely damaged in the 1906 earthquake (VIII to IX intensity) (Lawson et al., pp. 246-270) because they lie quite near the San Andreas fault and are partly situated on soft ground, principally mud of San Francisco Bay. On the coast, intensities ranged from V to X, depending on distance from the fault and ground conditions. Between Lake Merced and a point about one mile south of Mussel Rock, in the area now occupied by Daly City and Edgemar, intensities were IX and X. From there to San Pedro Point, including what is now Pacifica and Sharp Park, the intensity was VIII; from San Pedro Point to Montara Point intensity was VII. The Half Moon Bay area, from Moss Beach to Martin's Beach, experienced intensities of VII to IX-, reflecting the softness of Pleistocene marine terrace deposits there; the highest intensity (VIII to IX-) occurred along four miles of coast west of and including the town of Half Moon Bay. Intensity VII occurred in the San Gregorio and Pescadero areas to the south, also due to soft ground. South of Pescadero to Santa Cruz, intensities of V and VI prevailed, due chiefly to the presence of older, moderately consolidated surfical materials.

Landslides and rockslides were triggered by the 1906 earthquake at numerous points on the coast between Mussel Rock and Half Moon Bay, the largest of these occurring in the vicinity of Devil's Slide (Figure 9).

The area just east of Monterey Bay displays high seismicity localized on the San Andreas fault, which lies from 10 to 25 miles east of the bay margin. Seismic activity takes the form of frequent (one every 5 to 10 years) medium shocks of intensity VI to VII with nearby epicenters, as well as infrequent (about 2 per century) major earthquakes with intensity of VIII to X centered on the San Andreas and

Hayward faults to the north (Figure 9).

Epicenters of the major earthquakes of 1868 and 1906, and probably that of 1838, were on the San Andreas fault north of Monterey Bay. Surface faulting extended southward at least to San Juan Bautista in 1906, and probably as far as Santa Cruz in 1838 and 1868. This southward extension of faulting towards Monterey Bay has resulted in high seismic intensities in that area. In 1906, the bay margin from Santa Cruz to a point about halfway between Moss Landing and Pacific Grove experienced intensity VIII to IX-. Pacific Grove and Monterey, which are founded on granite, had intensity VI (no structural damage); the area with intensity IX- is underlain by the soft sediments of the Salinas River and Pajaro River deltas. The recent river channel deposits were subjected to extensive cracking, lurching, and settling of as much as several feet, causing damage to roads, bridges, piers, railroads, and other structures.

About 12 moderate shocks with maximum intensities of VII and VIII have occurred within 25 miles of the Monterey Bay margin (Eppley, 1966, p. 6), a few of which have caused minor to moderate damage there, but no damage in Monterey. The 1838 earthquake may have had intensity VII in Monterey, which appears to be the greatest ever experienced in that town (Figure 9).

The coastal region from Point Sur to Point Conception is one of relatively low seismicity. The Nacimiento fault zone, which appears to be one source, extends from a point 10 miles east of Lopez Point to a point 15 miles north of Santa Barbara, and is located from 5 to 40 miles inland. The San Andreas fault, 40 to 60 miles inland, is the locus of greater seismicity; but only a great earthquake on it would cause damage at the coast (as did the 1857 event).

## EXPECTED SEISMIC EFFECTS

### Seismicity:

It is expected that the coastal zones of San Mateo, Santa Cruz and Monterey Counties will continue to experience damaging intensities from earthquakes generated on faults outside the immediate area as well as from local faults. Displacements on the San Andreas fault can be expected to generate earthquakes of magnitude greater than 8.0 and those on the Hayward fault and the Seal Cove - San Gregorio-Palo Colorado fault can be expected to generate earthquakes with magnitudes between 7.0 and 8.0.

There is presently no way to determine how frequently large damaging earthquakes will occur on these faults or where and when the next major earthquake will take place. Unfortunately, recent seismicity is not a reliable key to future activity. For example, the segment of the San Andreas fault that generated the 1906 San Francisco earthquake is seismically relatively quiet, although most earth scientists agree that it will generate large earthquakes in the future.

Small and intermediate earthquakes capable of causing local damage in the coastal zone can be expected from minor faults throughout the coastal ranges of San Mateo, Santa Cruz, and Monterey Counties as well as from the San Andreas, Seal Cove - San Gregorio - Palo Colorado, and Monterey Bay faults. Historical records indicate that these earthquakes will occur much more frequently than major earthquakes but, again, there is presently no way to predict their frequency and location.

### Ground Shaking and Ground Failure:

By far the greatest potential hazards presented by earthquakes effecting the coastal zone are high levels of ground shaking (high intensities) and ground failure.

The highest intensities will occur close to the faults on which earthquakes are generated, and in areas underlain by thick accumulations of unconsolidated deposits which amplify seismic waves. The regions most likely to experience seismic amplification are primarily the Pajaro Valley, the Elkhorn Slough area, and the Salinas River Valley, and secondarily the Half Moon Bay area, and the Santa Cruz - Capitola area.

Ground failure due to abrupt surface rupture along fault traces will be restricted to fault zones and will most likely accompany only large fault displacements, primarily along the San Andreas fault. Ground failure due to slow fault creep has not been observed along any of the faults in the coastal zone.

Ground failure due to seismic shaking will occur on unstable hillslopes and coastal cliffs (landslides), and on low-lying floodplains (lateral spreading and subsidence primarily due to liquefaction).

Landslides will probably range from rotational slumps to mudflows on steep to gentle slopes and will include blockfalls along steep sea cliffs. New landslides will probably be triggered by earthquakes and many old landslides may be reactivated. All types of slope failure will be more severe if earthquakes of high intensities occur during the rainy winter season when the ground is saturated. Seismically induced slumps may also occur in Submarine Monterey Canyon and could generate local tsunamis.

The coastal regions most likely to experience liquefaction and its related ground failures are those underlain by loose, water-saturated alluvial deposits, the floodplains of Pescadero Creek, the San Lorenzo River, the Pajaro River, Elkhorn Slough, the Salinas River, the Carmel River, and numerous smaller coastal streams. The high intensities attributed to these areas during the 1906 San Francisco earthquake were probably due in part to the extensive ground failure caused by liquefaction (Figure B).

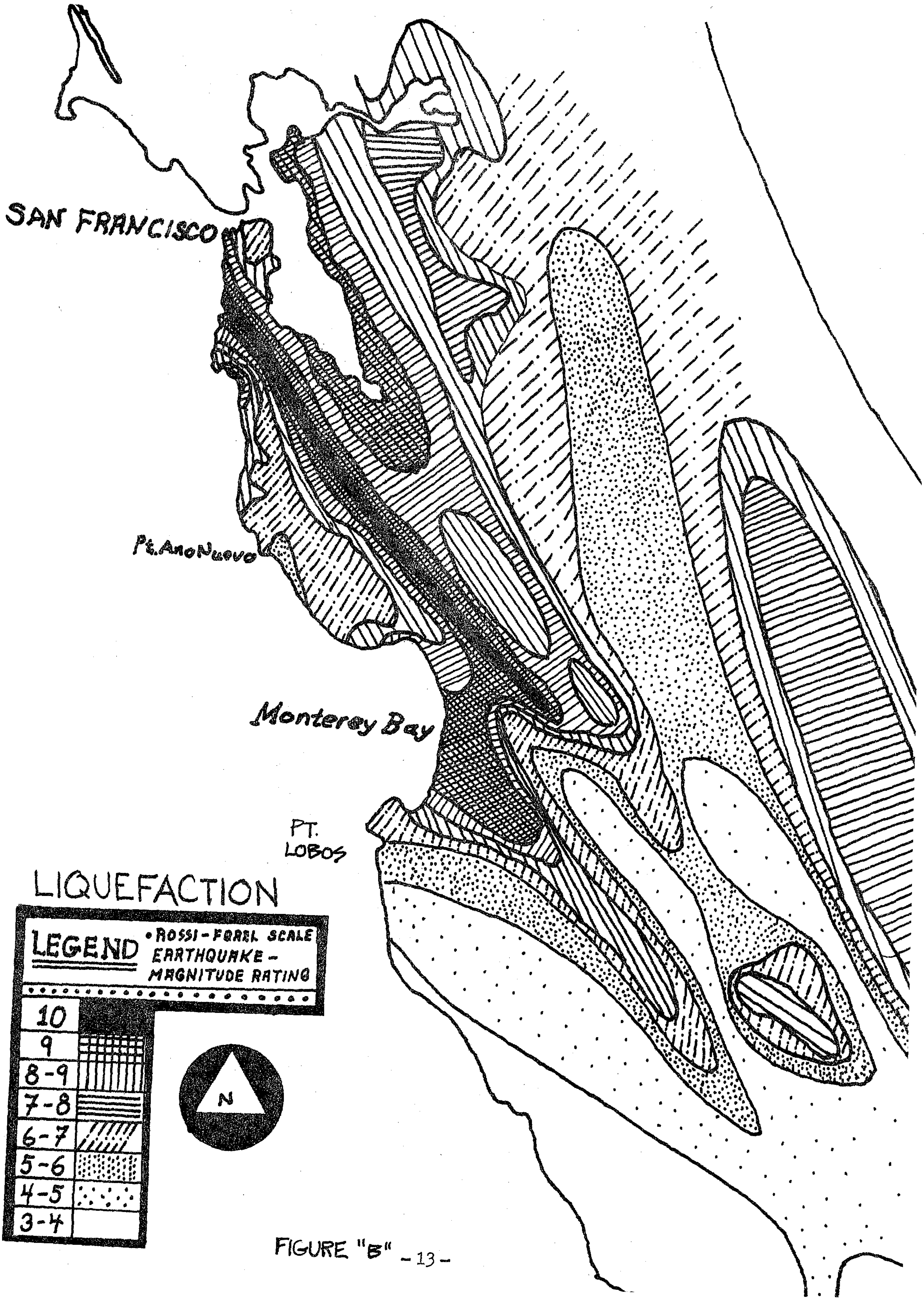

SAN FRANCISCO
Pt. AnoNuevo
Monterey Bay
PT. LOBOS
LIQUEFACTION
LEGEND
• ROSSI - FOREL SCALE
EARTHQUAKE -
MAGNITUDE RATING
10
9
8-9
7-8
6-7
5-6
4-5
3-4
N

FIGURE "B"

Landslides

Landslides can be surprisingly destructive and fast moving such as those in Big Sur Valley; fortunately, they are more predictable than earthquakes. Most Californians have seen a home or road which has slipped down a hill. Others have even waded through a street covered with mud from a landslide. More often than not, these conditions could have been avoided if landslide hazards had been known and acknowledged.

Landslides are an extreme form of a natural erosion process; the down-slope movement of earth materials, primarily by gravity. When the earth material moves imperceptibly it is defined as "creep;" but when movement is large and perceptible it is called a landslide.

The coastal zone of California may be somewhat more prone to landslides than other areas of the State, due primarily to the relative instability of coastal rock units and the additional periodic fragmenting from earthquakes.

This is particularly true in seacliff areas, which are often battered and undercut by ocean storm waves. The California Division of Mines and Geology projects a total statewide property loss from landslides of approximately $10 billion between 1970 and 2000. Much of this damage will undoubtedly occur in the coastal zone.

Landslides can be classified according to type of movement, earth material involved, and water content. All types of landslides occur within the coastal zone and may in fact be more serious there because of the many residential areas that continue to expand up hillsides and perch on seacliffs, often without adequate pre-construction analysis of the land. Large storms, earthquakes, or accumulated ground water can trigger a landslide, which has perhaps been camouflaged by vegetation or surface erosion.

The possibility of landsliding can often be determined before it happens. Rock formations, soil types, water content, slopes, and other factors can all be analyzed by geologists to identify potential slide areas. The results are compiled on "slope stability" maps. Both the U. S. Geological Survey and the California Division of Mines and Geology have partially completed slope-stability maps for coastal counties. Local governments may request these mapping projects, but thus far the maps mainly cover areas of intense development.

The Joint Committee on Seismic Safety recommended strengthening the Uniform Building Code to control construction in landslide-prone areas, and also help local and county governments deal with landslide hazards. If these recommendations were implemented, and followed-up by slope-stability mapping and geologic analysis of property chosen for development, the damages from landslides could be greatly reduced. (For example, proper evaluation of landslide potential in Los Angeles County has virtually eliminated damage from slides in areas developed under the new controls.)

Slope Stability in the Central Coast

Much of the Central Coast Region has experienced landslides. The tenuous hold of Highway I through this Region is threatened by landslides in many sections. Aside from this graphic and costly example of slope instability, many people are not aware of this hazard. In the winter of 1968-1969, landslides caused over 3½ million dollars damage in San Mateo County (U.S.G.S. Study by Taylor and Brabb).

Only San Mateo County has extensively mapped landslide potential and used this information in their planning policies. Their program is a model not only for the Region but the State. Both Monterey and Santa Cruz are compiling this information as part of their Seismic Safety Elements of their General Plans.

Tsunamis

Tsunamis (seismic sea waves) are caused by undersea earthquakes, submarine volcanic eruptions or large underwater landslides. Tsunamis can be terrifying natural forces, travelling at high speeds up to 400 miles per hour, with long periods (time interval between waves) and huge breakers that form as the wave approaches shallow water. Coastal cities bordering shallow water, such as Crescent City, are the most unprotected from tsunamis. Seiches are shorter, lower energy waves that form in smaller bodies of water such as bays and lakes.

Fortunately these seismic sea waves are rare events, and are usually of tolerable heights. If they should coincide with high tides or storm waves, however, their potential for damage in many coastal areas is greatly increased. The California Division of Mines and Geology has projected a tsunami damage of $41 million between 1970 and 2000.

There is no prevention of tsunamis, but their destructive impact can be minimized by warning of their approach and wisely planning any uses of tsunami runup areas. The National Oceanic and Atmospheric Administration (NOAA) operates a successful tsunami warning system, and the U. S. Army Corps of Engineers compiles tsunami runup maps for coastal areas. These maps should be the difference between building anywhere along the coast, and wisely avoiding the possible tragedy of seawater flooding from a massive tsunami. These maps are being completed for all coastal areas threatened by large waves, and can be further interpreted with the aid of tsunami studies of local and State governments.

In the coastal zone of San Mateo, Santa Cruz, and Monterey Counties, the areas most susceptable to tsunami innundation are the southern Pacifica area, the northern Half Moon Bay area, parts of the Santa Cruz area, the lower reaches of Elkhorn Slough, parts of Monterey, and the lower Carmel Valley (Figure A). A potential tsunami hazard also exists where houses and other structures are built at the base of otherwise protective cliffs, such as in the northern Monterey Bay region.

Most tsunamis likely to effect this coastal area probably will be generated in areas such as Alaska and South America. Tsunamis may also be generated by sudden vertical displacements of the ocean floor accompanying movements on local faults, or by submarine slumps in Monterey Canyon.

Shoreline Erosion

Most Californians have noticed the loss of sand along a favorite beach, or the more dramatic slippage of a cliff top home into the ocean. Shoreline erosion is a natural process affecting all areas of the coastline, although at varying rates. Improper use of the shoreline may speed up the erosion process, and result in damage to property that might have been avoided.

Beach Erosion

Rivers and streams provide most of the sand to coastal beaches, although cliff erosion accounts for most of the sand in isolated "pocket beaches." Once the sand is deposited on beaches, it is transported on and offshore by various sizes of waves, and alongshore by offshore currents and the angling waves striking the beach. For example, the large northern storm waves of winter remove sand from beaches and take it out to sea and also push it south along the shore. In the summer, the process is generally reversed, with sand once again being deposited onshore, and being pushed north by southern waves. This seasonal movement alongshore is called littoral drift.

Most beach sand moves along in distinct areas of the coast known as "littoral cells." These areas usually receive their sand from a river mouth toward the northern end of the cell, transport the sand southward alongshore, until it is lost offshore into submarine canyons. This cycle of sand deposition on beaches, alongshore transport, and sand loss to the open sea is a constantly changing system.

Man-made obstacles such as breakwaters, groins, seawalls, and harbor entrances impede the natural transport of sand. It has been learned that many facilities intended to retain sand in one place often leads to accelerated erosion elsewhere and even to accelerated loss of sand offshore so that beaches become permanently denuded.

Between reduction in the production of sand by coastal streams due to dams and diversions (as discussed in the Coastal Land Environment plan element) and the premature loss of sand to the ocean because of unanticipated effects of some shore protection works and channel dredging projects, the Water Resources Council projects the annual loss due to beach erosion in California to reach $15.7 million in 1980 and $26.7 million by 2000.

<u>Other Shoreline Erosion</u>

Beaches make up only 1/3 of California's coastline, with the remainder comprised of cliffs, marshes, bluffs and other areas of varying terrain and rock type. The continuous battering of waves against the coastline erodes the land into an always changing shape. Some areas erode very quickly, such as the 10 feet per year rate of erosion along portions of San Mateo County's bluffs, and yet just a few miles away a hard-rock headland will have negligible erosion. Rainwater running off the cliff also erodes the cliffs from the landward side, so that the shoreline is assaulted from both directions. Ill-advised developments along the shoreline often suffer the consequences of construction that does not adequately anticipate local erosion problems.

Shoreline erosion processes are best left alone to constantly alter the shoreline of California. These processes are not yet fully understood; interference with them often causes greater harm than benefit. The U. S. Army Corps of Engineers and the California Department of Navigation and Ocean Development operate a cooperative program to study shoreline processes in areas of fast erosion. There are also elaborate methods of reducing excessive erosion, such as sand bypass systems, extensive dredging, and construction of improved shoreline obstacles to control sand transport, but these tend to be prohibitively expensive. The best way to maintain the sand supply is not to impair natural shoreline processes. Coastline structures may impede local sand supply and affect the entire littoral cell equilibrium so each proposed project should be evaluated for its impact upon sand movement in the whole cell, as well as for its effect on nearby areas.

Cliff Stability in the Central Coast Region:

Coastal erosion is a dramatic process in the Central Coast Region. The process of erosion is unrelenting; man may attempt to prevent it, but his actions can only slow the process down. This Region contains a variety of land formations on the oceanfront, and the rate of cliff retreat varies from near zero to over ten feet a year.

A lack of measurable erosion does not tell the whole story. Cliffs, beaches, and the sea exist in a delicate balance which can be altered by covering or grading bluff tops, changing drainage patterns, or removing the protective sand beach. When the balance is broken, the sea traditionally advances on the land and cliff retreat occurs. (See Figures D-H)

Since the erosion process itself is not completely understood, efforts to control it often adversely affect surrounding features, and may even increase erosion in some areas.

Seawalls of rip rap or concrete are the most common countermeasures used in the Central Coast Region. (See Figure C) These structures deflect or defuse wave energy, but can also induce accelerated erosion on adjoining cliffs or loss of downdrift beach sand. In addition, they have a definite relationship to the issues of recreational access and coastal aesthetics, for which future Commission policies will be specifically developed.

The basic policy of this Commission should be that new development will be designed with a bluff top set back far enough from the cliff edge that no cliff protection will be required during an economic life of 50 years. Cliff protection measures for existing development will be considered on an individual basis. In both cases the overriding concern is that development does not contribute to the instability of any cliff or beach, and does not impose a potential public hazard. The cliff stability maps and policy shall serve as interim development guidelines. (See Figures I-M)

Steps Towards Reducing Geologic Hazards

The four geologic hazards of the coastal zone have one large factor in common: earthquakes, landslides, tsunamis and shoreline erosion destroy lives and property primarily because of inappropriate uses of the land. The hazards are all natural processes. Research, mapping, and changing government attitudes toward geologic hazards are impairing man's ability to live with these phenomena.

Research and mapping of hazards - such as earthquake fault maps, slope-stability maps for landslides, tsunami runup areas determined by recurrence mapping, and erosion rate - allows the use of land to be planned in a manner that minimizes avoidable risks. Also necessary, however, is analysis of the specific site proposed for development. In areas identified in any study as prone to geologic hazards a geologic survey team including a design civil engineer, a soils engineer, and an engineering geologist should analyze sites proposed

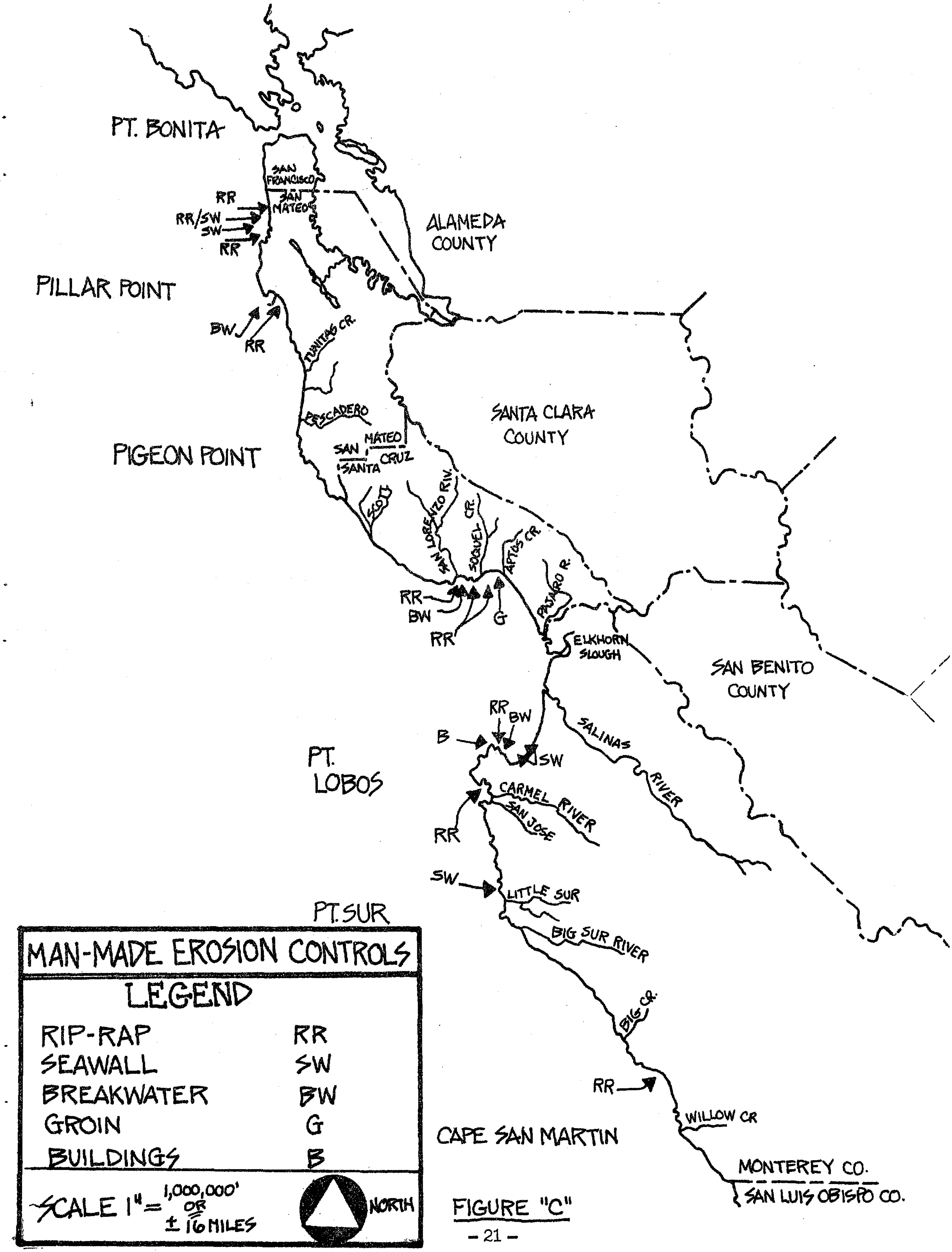
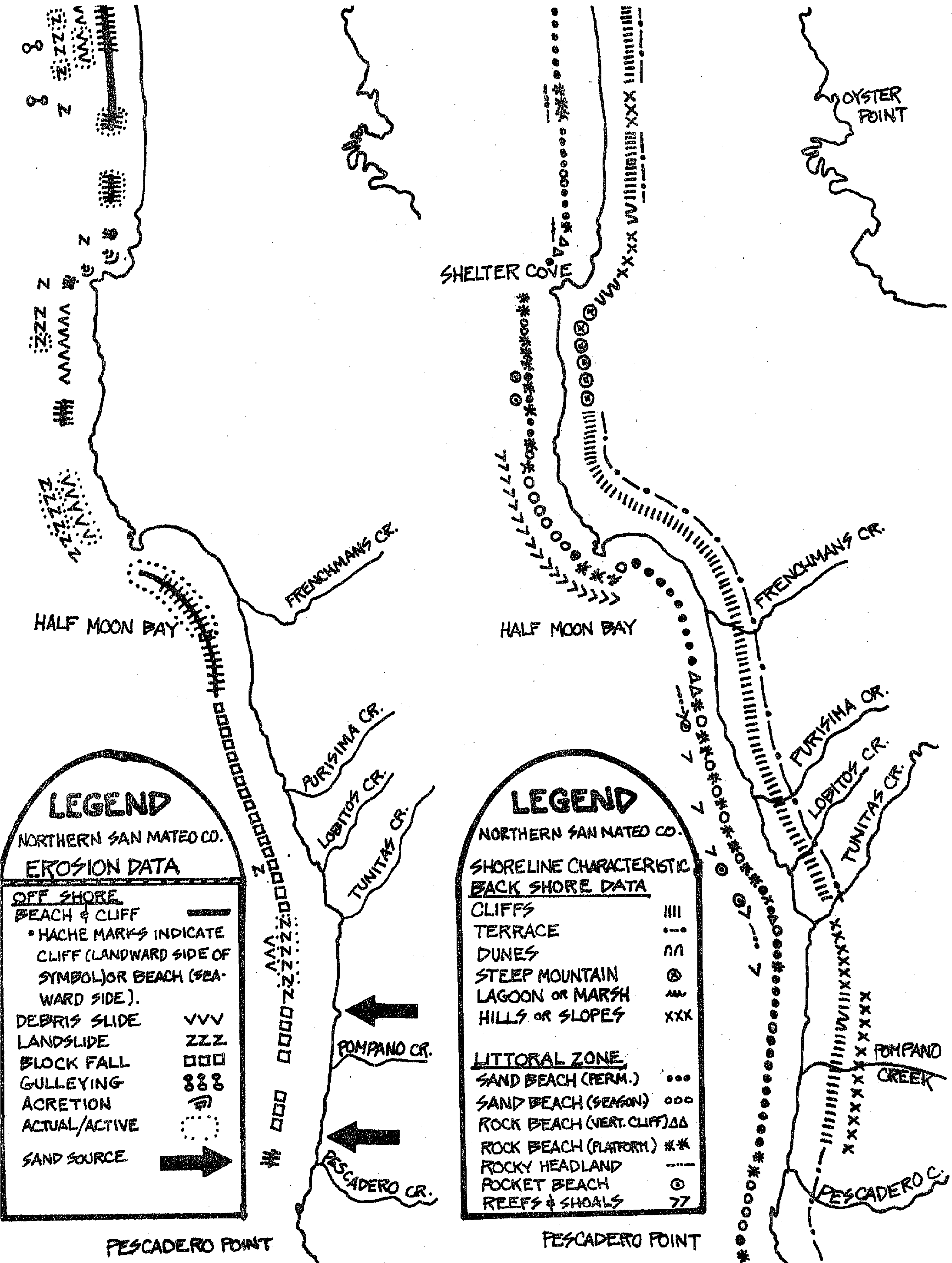

PT. BONITA
SAN FRANCISCO
SAN MATEO
RR
RR/SW
SW
RR
ALAMEDA COUNTY
PILLAR POINT
BW
RR
TUNITAS CR.
PESCADERO
SANTA CLARA COUNTY
PIGEON POINT
SAN MATEO
SANTA CRUZ
SCOTT
SAN LORENZO RIV.
SOQUEL CR.
APTOS CR.
PAJARO R.
RR
BW
RR
G
ELKHORN SLOUGH
SAN BENITO COUNTY
RR
BW
B
SW
SALINAS RIVER
PT. LOBOS
CARMEL RIVER
SAN JOSE
RR
SW
LITTLE SUR
PT. SUR
BIG SUR RIVER
BIG CR.
RR
WILLOW CR
CAPE SAN MARTIN
MONTEREY CO.
SAN LUIS OBISPO CO.
MAN-MADE EROSION CONTROLS
LEGEND
RIP-RAP RR
SEAWALL SW
BREAKWATER BW
GROIN G
BUILDINGS B
SCALE 1" = 1,000,000' OR ± 16 MILES
NORTH

FIGURE "C"



OYSTER POINT
SHELTER COVE
HALF MOON BAY
FRENCHMANS CR.
PURISIMA CR.
LOBITOS CR.
TUNITAS CR.
POMPANO CR.
PESCADERO CR.
PESCADERO POINT
LEGEND
NORTHERN SAN MATEO CO.
EROSION DATA
OFF SHORE
BEACH & CLIFF
• HACHE MARKS INDICATE CLIFF (LANDWARD SIDE OF SYMBOL) OR BEACH (SEAWARD SIDE).
DEBRIS SLIDE VVV
LANDSLIDE ZZZ
BLOCK FALL
GULLEYING 888
ACRETION
ACTUAL/ACTIVE
SAND SOURCE
HALF MOON BAY
FRENCHMANS CR.
PURISIMA CR.
LOBITOS CR.
TUNITAS CR.
POMPANO CREEK
PESCADERO C.
PESCADERO POINT
LEGEND
NORTHERN SAN MATEO CO.
SHORELINE CHARACTERISTIC
BACK SHORE DATA
CLIFFS
TERRACE
DUNES
STEEP MOUNTAIN
LAGOON OR MARSH
HILLS OR SLOPES XXX
LITTORAL ZONE
SAND BEACH (PERM.)
SAND BEACH (SEASON)
ROCK BEACH (VERT. CLIFF)
ROCK BEACH (PLATFORM)
ROCKY HEADLAND
POCKET BEACH
REEFS & SHOALS


FIGURE "D"

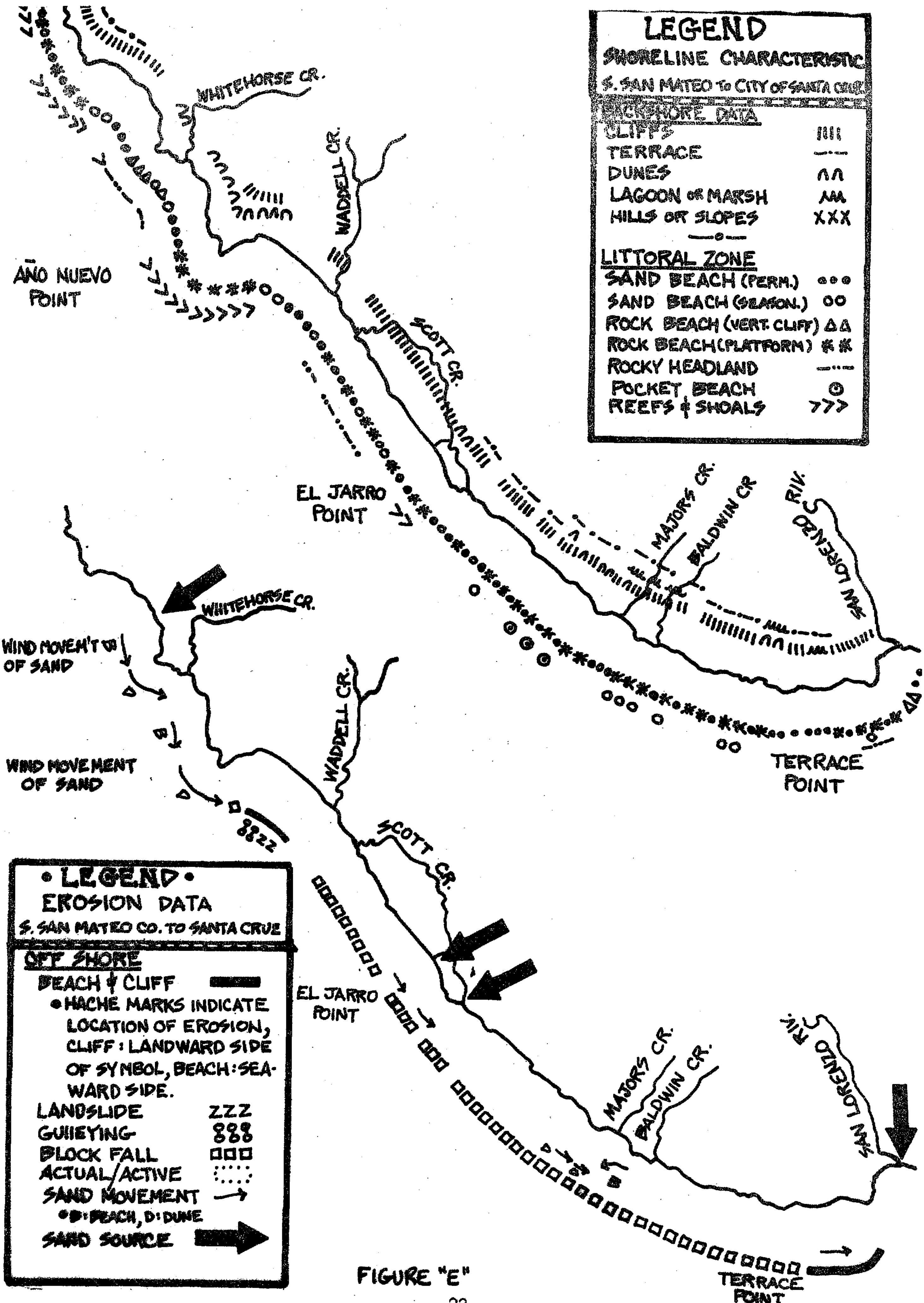

LEGEND
SHORELINE CHARACTERISTIC
S. SAN MATEO TO CITY OF SANTA CRUZ
BACKSHORE DATA
CLIFFS
TERRACE
DUNES
LAGOON OR MARSH
HILLS OR SLOPES
XXX
LITTORAL ZONE
SAND BEACH (PERM.)
SAND BEACH (SEASON.)
ROCK BEACH (VERT. CLIFF)
ROCK BEACH (PLATFORM)
ROCKY HEADLAND
POCKET BEACH
REEFS & SHOALS
WHITEHORSE CR.
WADDELL CR.
SCOTT CR.
AÑO NUEVO POINT
EL JARRO POINT
MAJORS CR.
BALDWIN CR.
SAN LORENZO RIV.
TERRACE POINT
WIND MOVEM'T OF SAND
WIND MOVEMENT OF SAND
• LEGEND •
EROSION DATA
S. SAN MATEO CO. TO SANTA CRUZ
OFF SHORE
BEACH & CLIFF
• HACHE MARKS INDICATE LOCATION OF EROSION, CLIFF: LANDWARD SIDE OF SYMBOL, BEACH: SEAWARD SIDE.
LANDSLIDE
ZZZ
GULLEYING
BLOCK FALL
ACTUAL/ACTIVE
SAND MOVEMENT
B: BEACH, D: DUNE
SAND SOURCE

FIGURE "E"

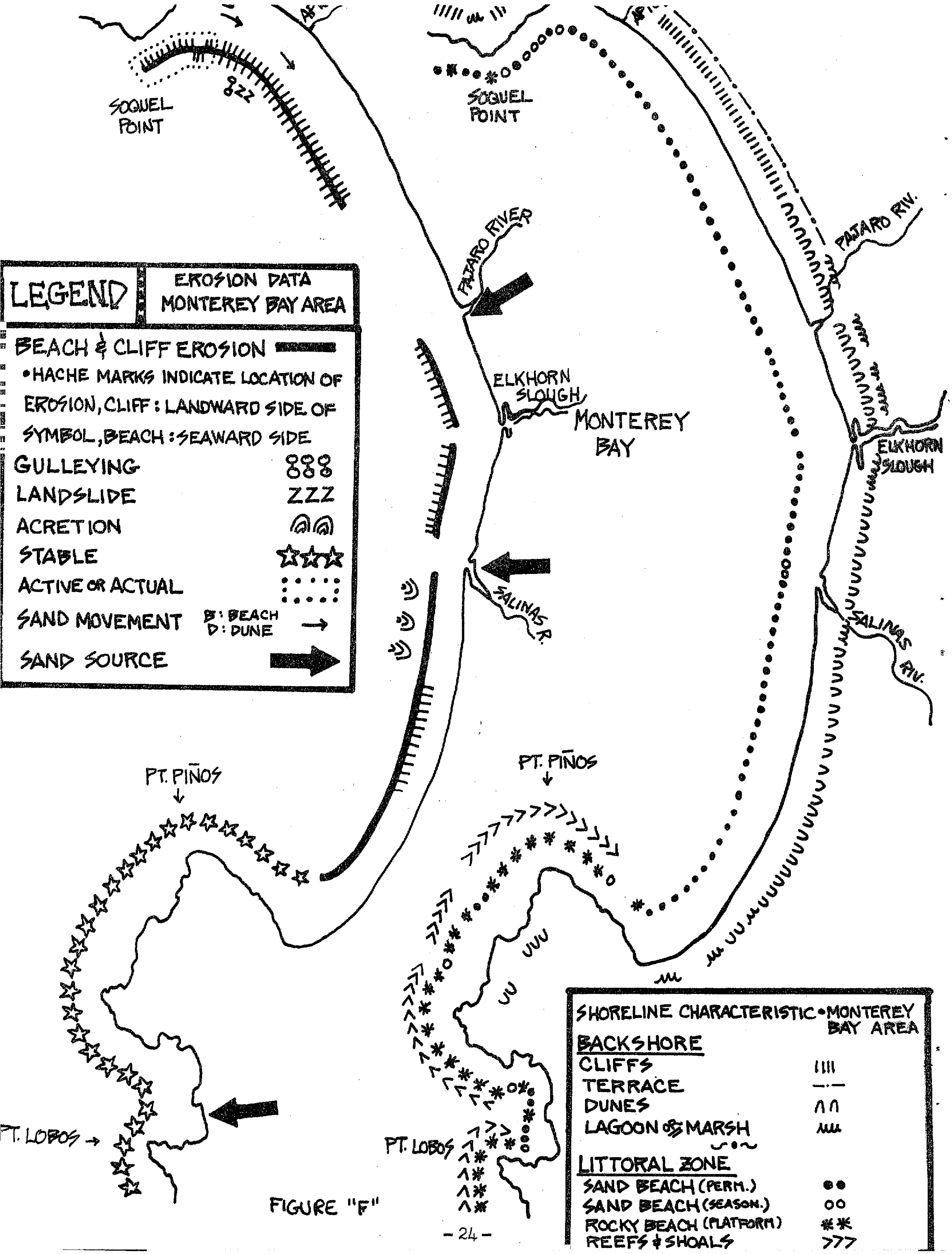

LEGEND
EROSION DATA
MONTEREY BAY AREA
BEACH & CLIFF EROSION
•HACHE MARKS INDICATE LOCATION OF EROSION, CLIFF: LANDWARD SIDE OF SYMBOL, BEACH: SEAWARD SIDE
GULLEYING
LANDSLIDE
ZZZ
ACRETION
STABLE
ACTIVE OR ACTUAL
SAND MOVEMENT
B: BEACH
D: DUNE
SAND SOURCE
SOQUEL POINT
PAJARO RIVER
ELKHORN SLOUGH
MONTEREY BAY
SALINAS R.
PT. PIÑOS
PT. LOBOS
SOQUEL POINT
PAJARO RIV.
ELKHORN SLOUGH
SALINAS RIV.
PT. PIÑOS
PT. LOBOS
SHORELINE CHARACTERISTIC • MONTEREY BAY AREA
BACKSHORE
CLIFFS
TERRACE
DUNES
LAGOON OR MARSH
LITTORAL ZONE
SAND BEACH (PERM.)
SAND BEACH (SEASON.)
ROCKY BEACH (PLATFORM)
REEFS & SHOALS

FIGURE "F"

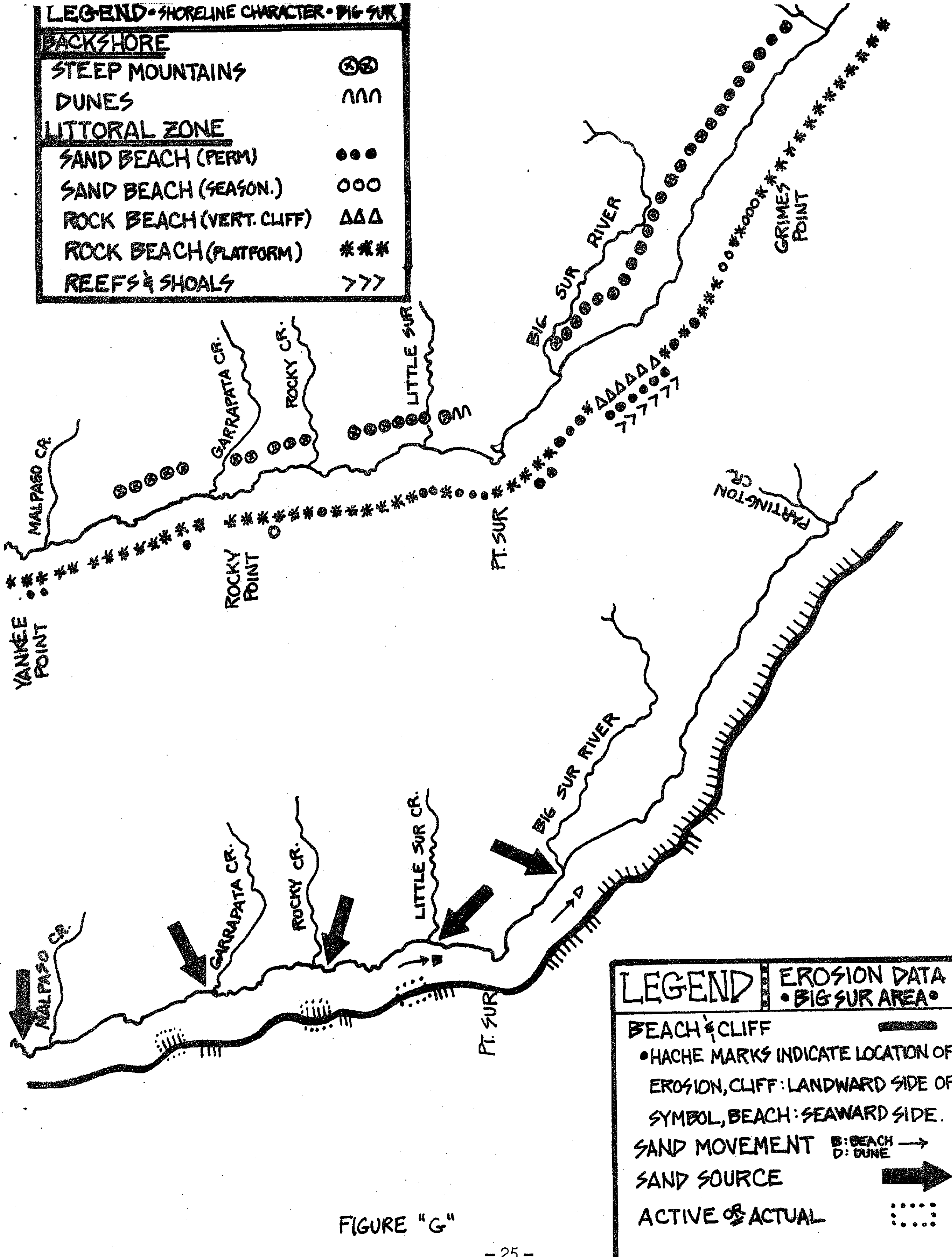

LEGEND • SHORELINE CHARACTER • BIG SUR
BACKSHORE
STEEP MOUNTAINS
DUNES
LITTORAL ZONE
SAND BEACH (PERM)
SAND BEACH (SEASON.)
ROCK BEACH (VERT. CLIFF)
ROCK BEACH (PLATFORM)
REEFS & SHOALS
MALPASO CR.
GARRAPATA CR.
ROCKY CR.
LITTLE SUR
BIG SUR RIVER
GRIMES POINT
PARTINGTON CR.
YANKEE POINT
ROCKY POINT
PT. SUR
MALPASO CR.
GARRAPATA CR.
ROCKY CR.
LITTLE SUR CR.
BIG SUR RIVER
PT. SUR
LEGEND
EROSION DATA • BIG SUR AREA •
BEACH & CLIFF
•HACHE MARKS INDICATE LOCATION OF EROSION, CLIFF: LANDWARD SIDE OF SYMBOL, BEACH: SEAWARD SIDE.
SAND MOVEMENT B: BEACH D: DUNE
SAND SOURCE
ACTIVE OR ACTUAL

FIGURE "G"

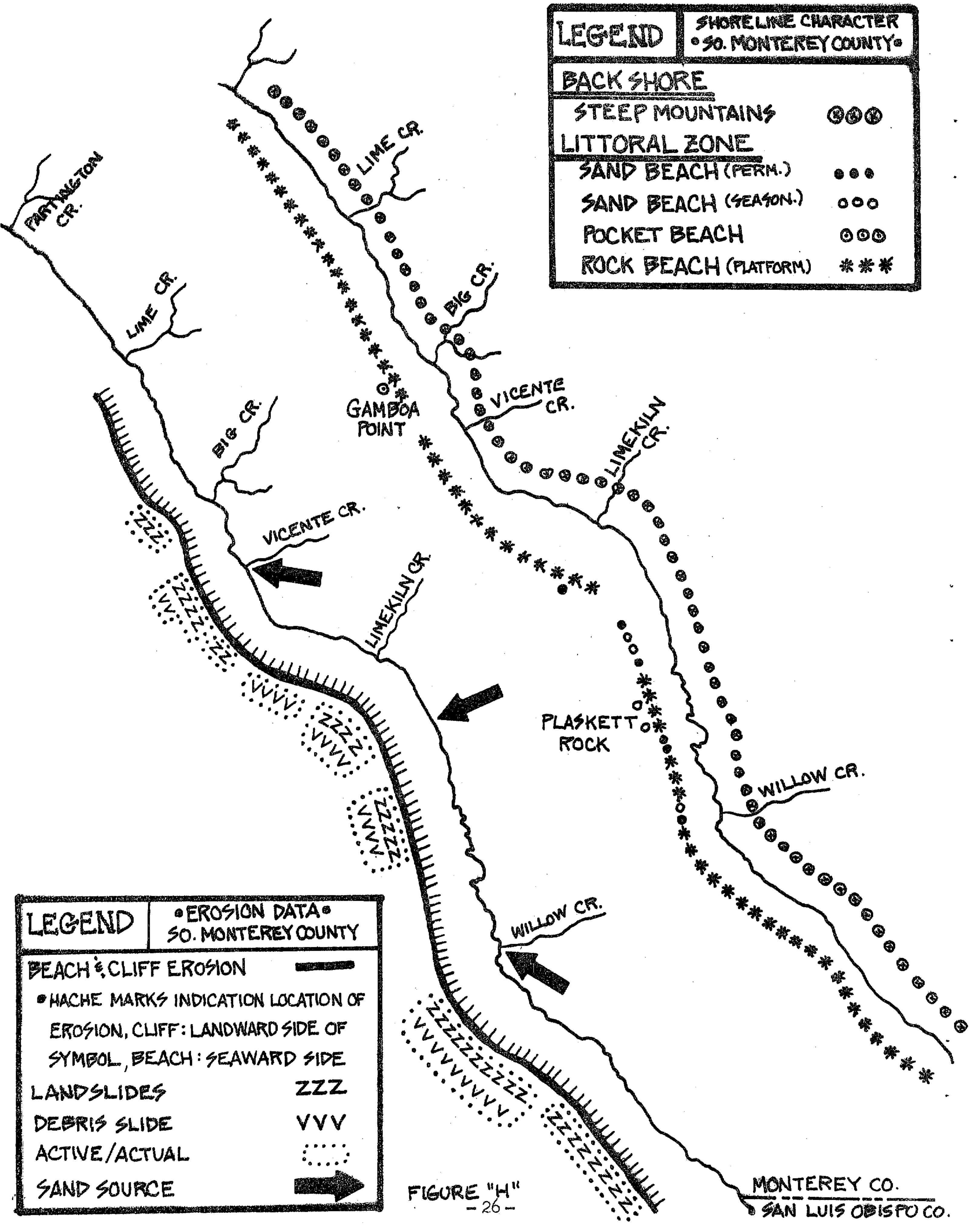

LEGEND
SHORELINE CHARACTER
SO. MONTEREY COUNTY
BACK SHORE
STEEP MOUNTAINS
LITTORAL ZONE
SAND BEACH (PERM.)
SAND BEACH (SEASON.)
POCKET BEACH
ROCK BEACH (PLATFORM)
PARTINGTON CR.
LIME CR.
BIG CR.
VICENTE CR.
LIMEKILN CR.
GAMBOA POINT
PLASKETT ROCK
WILLOW CR.
MONTEREY CO.
SAN LUIS OBISPO CO.
LEGEND
EROSION DATA
SO. MONTEREY COUNTY
BEACH & CLIFF EROSION
HACHE MARKS INDICATION LOCATION OF EROSION, CLIFF: LANDWARD SIDE OF SYMBOL, BEACH: SEAWARD SIDE
LANDSLIDES ZZZ
DEBRIS SLIDE VVV
ACTIVE/ACTUAL
SAND SOURCE

FIGURE "H"

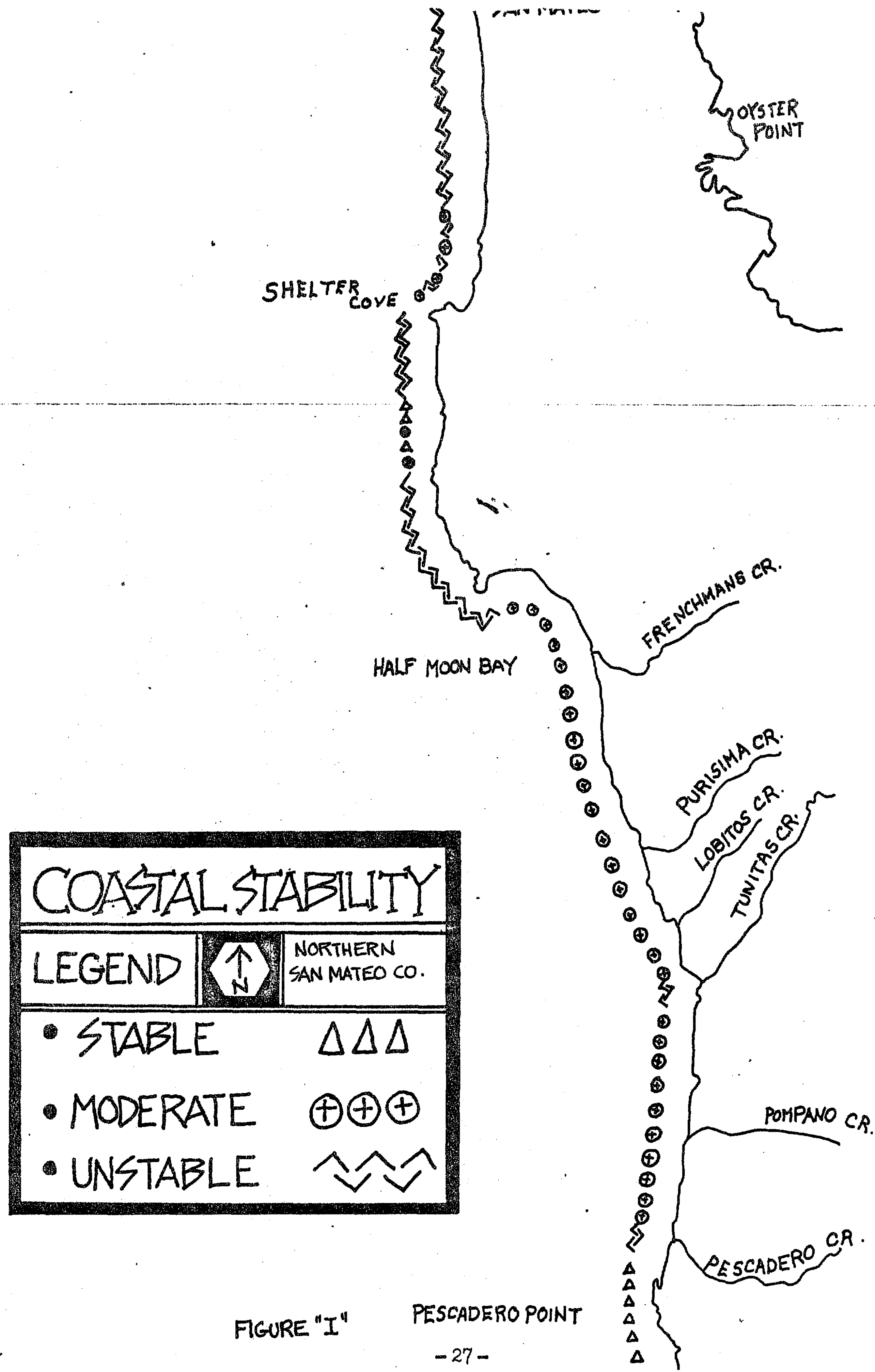

OYSTER POINT
SHELTER COVE
HALF MOON BAY
FRENCHMANS CR.
PURISIMA CR.
LOBITOS CR.
TUNITAS CR.
POMPANO CR.
PESCADERO CR.
PESCADERO POINT
COASTAL STABILITY
LEGEND
N
NORTHERN SAN MATEO CO.
STABLE
MODERATE
UNSTABLE

FIGURE "I"

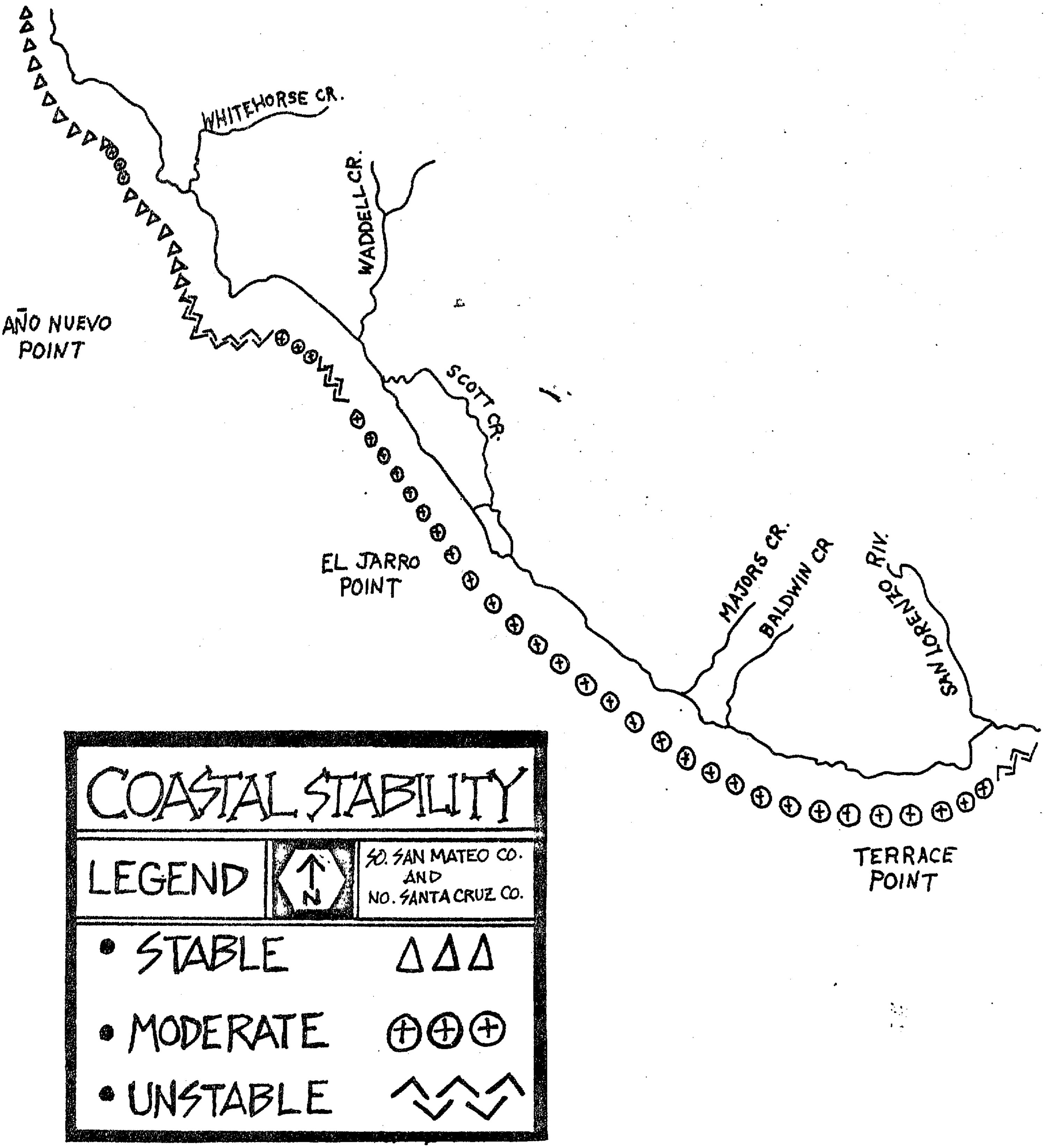

WHITEHORSE CR.
WADDELL CR.
AÑO NUEVO POINT
SCOTT CR.
EL JARRO POINT
MAJORS CR.
BALDWIN CR
SAN LORENZO RIV.
TERRACE POINT
COASTAL STABILITY
LEGEND
N
SO. SAN MATEO CO. AND NO. SANTA CRUZ CO.
STABLE
MODERATE
UNSTABLE

FIGURE "J"

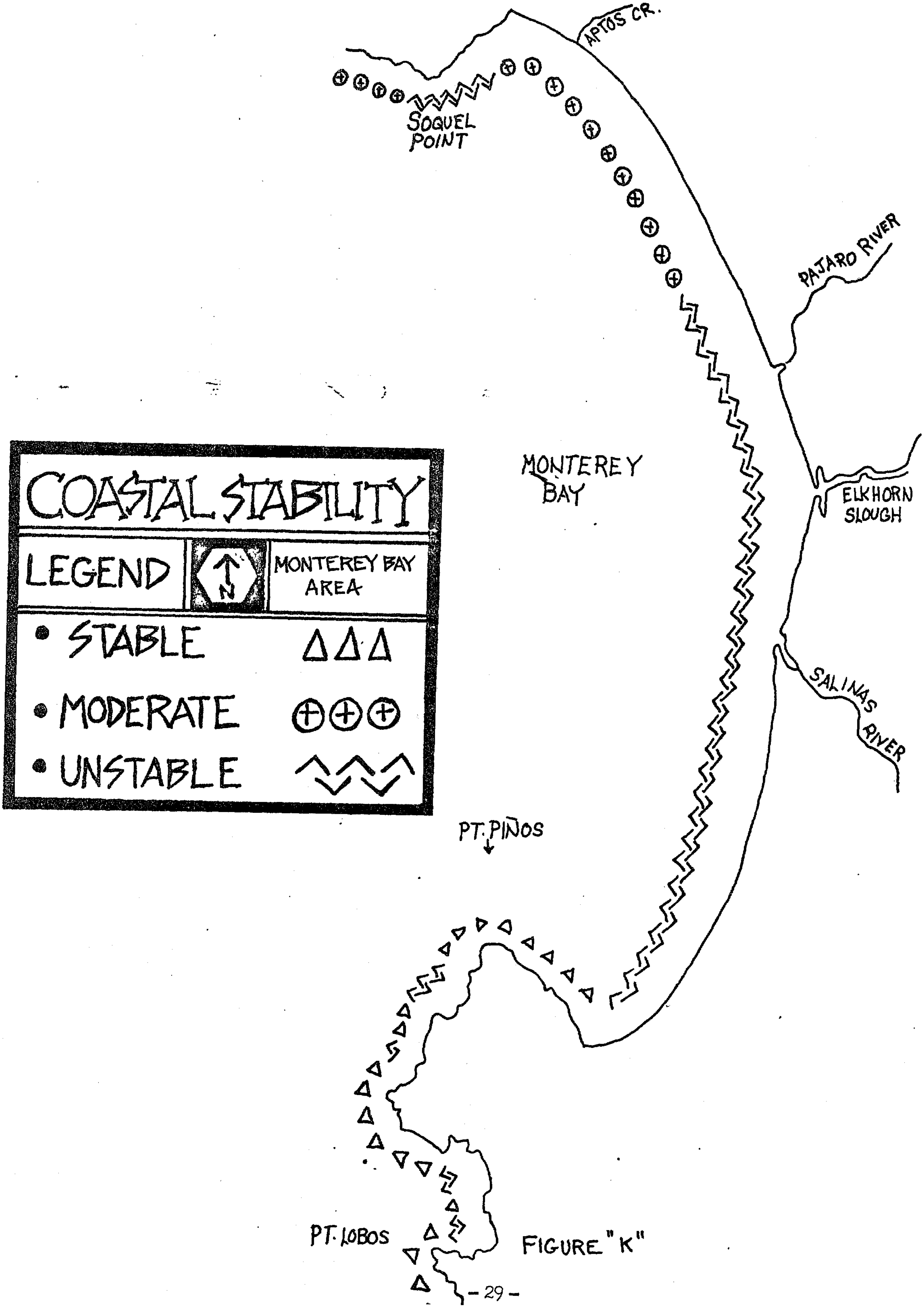

APTOS CR.
SOQUEL POINT
PAJARO RIVER
MONTEREY BAY
ELKHORN SLOUGH
SALINAS RIVER
COASTAL STABILITY
LEGEND
N
MONTEREY BAY AREA
• STABLE
• MODERATE
• UNSTABLE
PT. PIÑOS
PT. LOBOS

FIGURE "K"

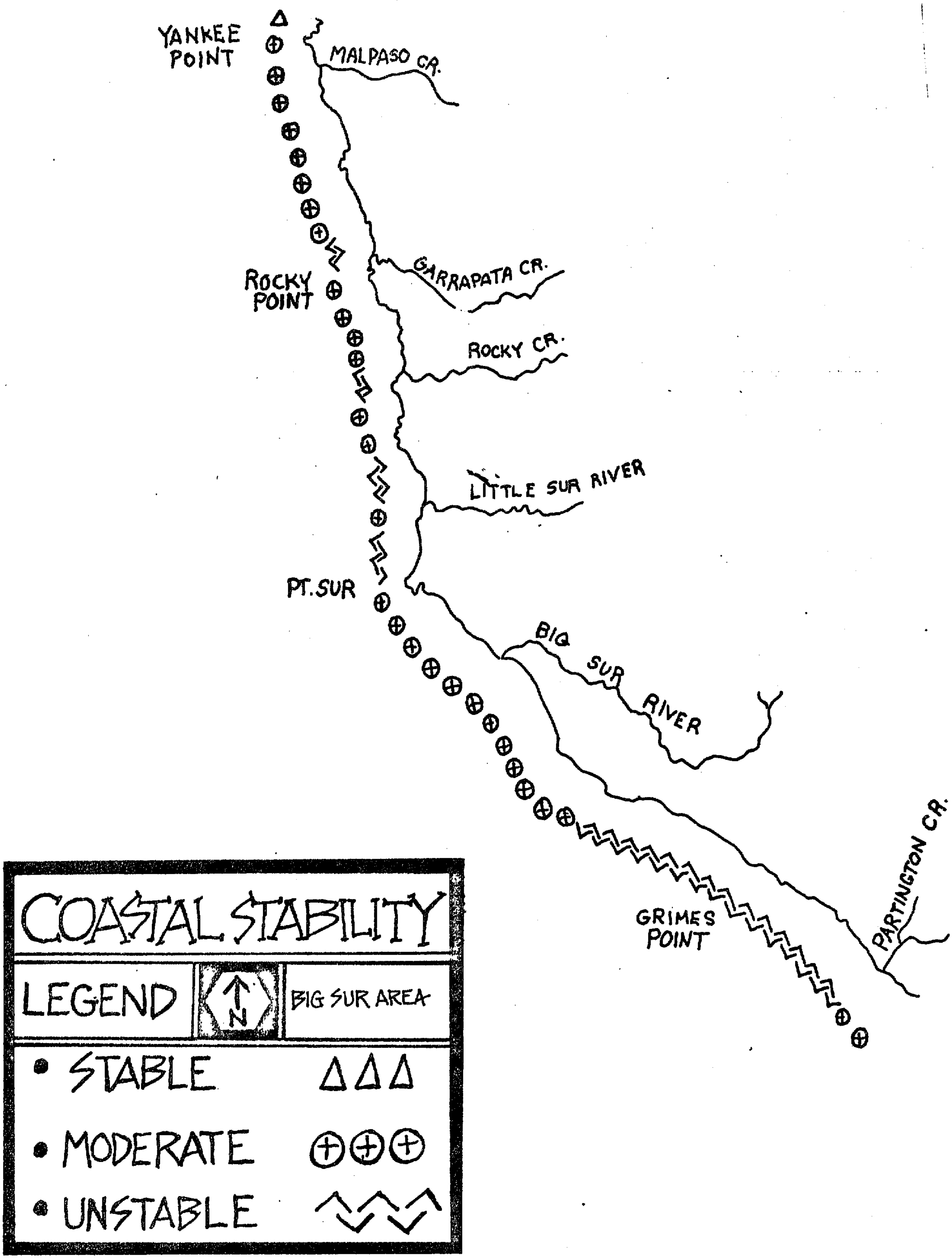

YANKEE POINT
MALPASO CR.
GARRAPATA CR.
ROCKY POINT
ROCKY CR.
LITTLE SUR RIVER
PT. SUR
BIG SUR RIVER
PARTINGTON CR.
GRIMES POINT
COASTAL STABILITY
LEGEND
N
BIG SUR AREA
• STABLE
• MODERATE
• UNSTABLE

FIGURE "L"

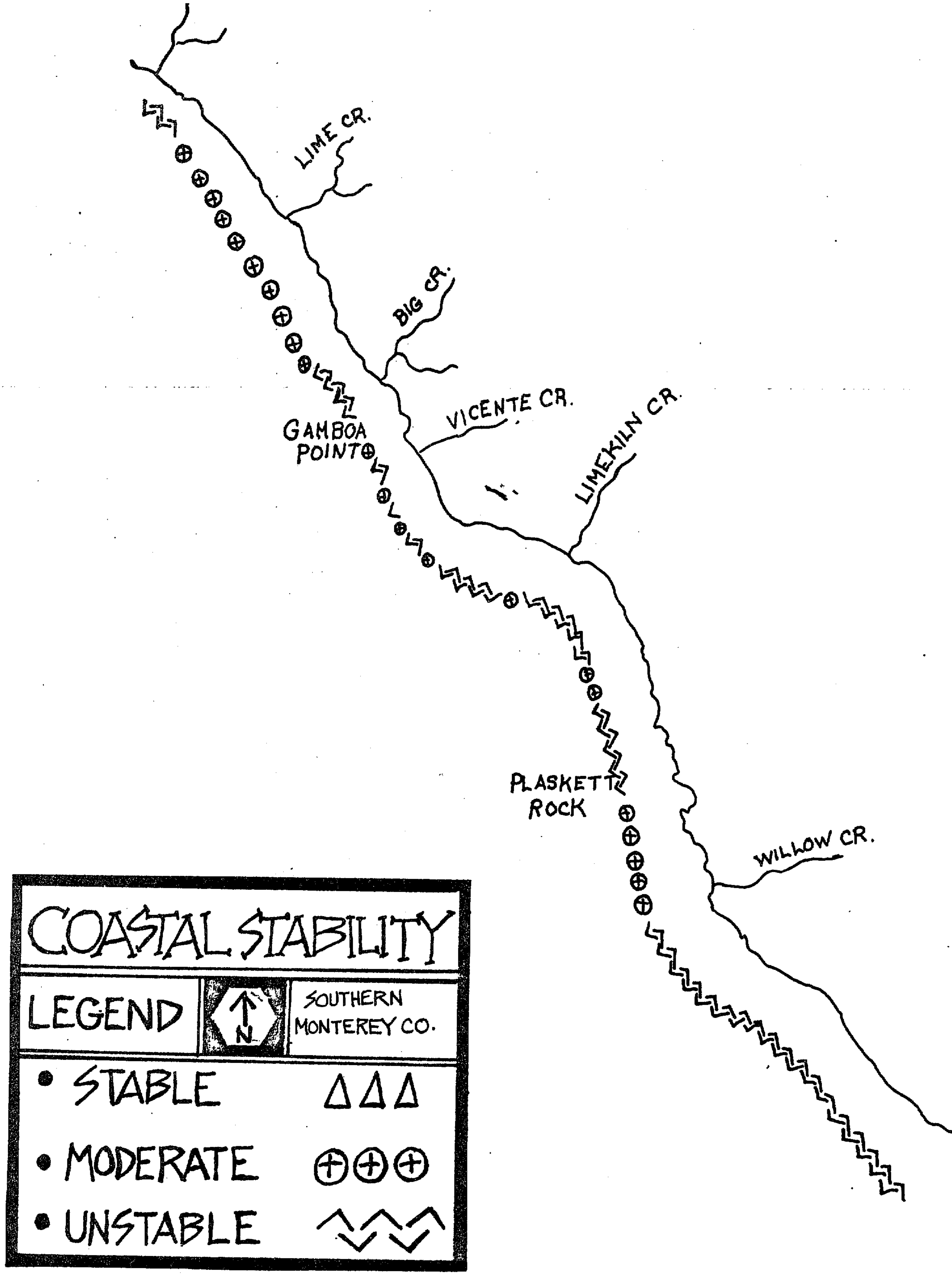

LIME CR.
BIG CR.
VICENTE CR.
LIMEKILN CR.
GAMBOA POINT
PLASKETT ROCK
WILLOW CR.
COASTAL STABILITY
LEGEND
N
SOUTHERN MONTEREY CO.
• STABLE
• MODERATE
• UNSTABLE

*FIGURE "M"

for any kind of construction and should prescribe site treatment and building construction techniques capable of offsetting the hazard. Where this has been done, damage has been reduced dramatically.

In addition the recommendations of the Joint Legislative Committee on Seismic Safety should be implemented, key features of which are to expend the provisions of the Alquist-Priolo Geologic Hazards Act of 1972 to treat all geologic hazards, not simply earthquake fault zones, through the medium of a Statewide Geologic Hazards Review Board. The Uniform Building Code should also be enforced throughout the State to ensure high quality construction capable of resisting geologic hazards.

In the meantime, local governments that are not already doing so and the Coast Commissions could improve the quality of their review and approval of projects located in geologic hazard areas by employing an advisory board composed of persons experienced in the several disciplines that are concerned with aspects of geologic safety. To adequately cover all the hazards, the board members should have expertise in geology, geophysics, oceanography, soils engineering, engineering geology, structural engineering, civil engineering and architecture.

For adequate project review and general advice concerning the four hazards, an effective board should be empowered and staffed to carry out with professional competence the following specific functions:

a. Review proposals for the adequacy of their specific <u>earthquake</u> safety provisions, and make recommendations concerning these provisions;

b. Establish and recommend earthquake safety criteria for structures;

c. Require installation and monitoring of such geophysical measuring instruments as strong-motion accelerometers, seismographs, etc. on any structure or urban development in the coastal zone to provide vital new information on the effect of earthquakes on urban developments.

d. Designate general types and causes of <u>landslides</u> and suggest criteria for approval of construction;

e. Identify alluvial fan areas of particular hazard and suggest appropriate development restrictions;

f. Disseminate information regarding the nature and extent of <u>tsunami</u> hazard to shoreline communities; and recommend standards for marinas and harbors, including debris clearance, to reduce damage from seismic waves;

g. Recommend a program for retention of a balanced <u>sand supply</u> for California beaches, including criteria for shoreline structures in view of their impact on wave currents and sand movement;

h. Develop guidelines for dredging of channel entrances to ensure adequacy of their design to permit tidal scouring and avoid shoaling;

i. Suggest proposals for stabilization of coastal bluffs with special consideration to the possible impact on beach erosion.

Where specific policies or analysis of sites has warned prospective builders of the geologic hazards of an area, and development proceeds nonetheless, there should be no presumption of public liability for private damage. That is, there should not be any public disaster loans or grants afforded in such case. Neither, as a practical matter, should insurance be available if it is borne by other members of the public who did not themselves undertake such risks.

<u>Conclusion</u>

Earthquakes, landslides, tsunamis, and shoreline erosion all pose their separate dangers to development in the coastal zone. By proper analysis and precautions, damage from these hazards can be reduced sharply. The coastal zone <u>can</u> be made a safer as well as attractive place in which to live, work and play.

(Use back for Comments)

# Policies Checklist — Geology

Central Coast Regional Commission

California Coastal Zone Conservation Commission

I would like to see:

| | Strongly Agree | | No Opinion | | Strongly Disagree |
|---|---|---|---|---|---|
| 1. Geologic Safety Measures Necessary. | | | | | |
| 2. Safety of Projects Should be Individually Checked. | | | | | |
| 3. Statewide Geologic Safety Measures Should be Upgraded. | | | | | |
| 4. Multi-Discipline Advisory Board Needed. | | | | | |
| 5. Interim Development Guidelines for Geologic Hazard Areas. | | | | | |
| 6. Interim Development Guidelines for Tsunami Runup Areas. | | | | | |
| 7. Interim Guidelines for Shoreline Protection and Channel Works. | | | | | |
| 8. Interim Coastal Erosion Guidelines. | | | | | |
| 9. Available Geologic Information Should be Fully Utilized. | | | | | |
| 10. Public Should Not Be Liable. | | | | | |

(Optional) Name ______________________ Organization ______________________

Address ______________________________

I wish to continue receiving Summary Reports. Yes _____ No _____

I wish to receive a copy of the Geology Technical Report. Yes _____ No _____

—— Please clip and fold this page as directed on reverse side.

DRAFT
April 1, 1974

Tentative Findings and Policies to be Recommended by the Central Coast Regional Commission to the California Coastal Zone Conservation Commission, Based on the Report, Coastal Geology and Geological Hazards.

Findings

1. Earthquake Hazard in the Coastal Zone. Much earthquake activity in California occurs within the coastal zone, which is part of the earthquake-prone belt extending around the entire rim of the Pacific Ocean. The coastal area contains many areas of highly complex fault zones.

2. Unpredictability of Earthquakes. Every section of the coastal zone has experienced earthquakes with various intensities. The recorded history is too brief, however, for definitive assessment of the earthquake frequency of any particular coastal section. The absence of any high-intensity shock in an area in the past 175 years does not rule out the possibility, or at the same time give reason to necessarily expect one.

3. Earthquake Research. Definitive studies of earthquake hazard and probability are still sparse. The technology and volume of data collecting is still in a state of development. Only the areas of recent high-level earthquake activity have been intensively studied. Instrumentation for detection and measurement is still being developed or refined and seismic theory itself is in the process of continual revision. Maps of earthquake faults only indicate a portion of the quake-prone areas in the State.

4. Potential Earthquake Damage. The scale of earthquake shaking hazard is indicated by the California Division of Mines and Geology projection of $21 billion in damage statewide between 1970 and 2000. An uncertain amount of this damage would occur in the coastal zone.

5. Legislation to Deal with Earthquakes. The Joint Legislative Committee on Seismic Safety has recommended broadening the provisions of the Alquist-Priolo Act (which is limited to concern about construction on or near fault traces) to encompass all geologic hazards, and has further recommended the creation of a State commission to establish and administer land use policies reflecting geologic hazards. This proposed commission would not conduct analysis of the geologic hazards of specific sites, however.

6. Landslide Hazard in the Coastal Zone. Much of the landsliding activity in California occurs in the coastal zone, due to the instability of the prevailing rock units and the steep-canyon topography of the coastal ranges. Many types of landslides, both ancient and recent, are observable, including rock falls, slides, and slow and fast flows, but many have been obscured by erosion and subsequent vegetation growth. Landslide causes include earthquake ground shaking, unstable rock formations, supersaturated ground material due to sustained rainfall, and poorly planned development of landslide-prone areas.

7. Problems of Flash Flood and Mudflows. A special problem in the California coastal range is the potential for fast mudflows on canyon walls and on the alluvial plain at canyon mouths. The potential for these mudflows is greatly increased by sudden heavy precipitation and by loss of ground cover, expecially from fire. Stabilization of these flow-prone areas is virtually impossible, yet these sites are often heavily developed, and suffer from later damage (i.e., Big Sur area in Central California).

8. Potential Landslide Damage. The California Division of Mines and Geology projects a statewide loss of $10 billion due to landsliding in the 30-year period after 1970, much of which will occur in the coastal zone.

9. Necessity of Slope-Stability Determination. Landslide mapping is a primary tool for assessing potential slope stability, while regulation of land use and site preparation are the chief means of minimizing slope stability hazards. At the present time, determination of slope stability and related land use regulation are random and imcomplete within the coastal counties. Mapping is normally undertaken only when intensive development is contemplated and landslide hazard is suspected. Regulation is normally adopted only after damaging landslides occur.

10. Tsunami Hazard in the Coastal Zone. Large-scale seismic sea waves (tsunamis) in the Pacific Ocean Basin have caused some degree of damage along much of the California coast, as with the great waves that followed the 1964 Alaska earthquake.

11. Extraordinary Tsunamis. Nearshore earthquakes can generate localized tsunamis, as with the Santa Barbara Channel event of 1812. That great wave may have reached an estimated height of 50 feet at Gaviota, the largest tsunami with some documentation on the California coast. Slumping in Monterey Canyon is a potential source of local tsunamis in the Central Coast Region.

12. Susceptibility to Tsunamis. Tsunami damage recurs in certain areas of the California coast more than in others, generally where there are shallow waters near the shore upon which waves can pile up. Crescent City on the northern coast has been repeatedly damaged. Various areas of the southern coast from Santa Barbara to San Diego suffered damage from a 1960 tsunami caused by a Chilean earthquake, and again from the great waves of 1964. Both these tsunamis struck the southern coast at low tide; had high tide prevailed, damage might have been much greater.

13. Coping with Tsunamis. Assessment of tsunami hazard on the California coast is based on a brief and partial history. No such assessment can anticipate future extraordinary events such as the Santa Barbara Channel earthquake and tsunami of 1812. Mapping of possible runup limits now underway by the U. S. Army Corps of Engineers for areas of identified high tsunami risk can provide useful information for land-use decisions in those areas; these maps can be augmented by local and county studies.

14. Potential Tsunami Damage. The California Division of Mines and Geology has projected a tsunami damage of $41 million between 1970 and 2000, based on present assumed hazards.

15. Beach Erosion Hazard in the Coastal Zone. Ocean beaches are one of the most highly valued features of the California's coastal environment. Many of these beaches are being lost by erosion due to man's activities in the coastal zone. A primary cause of accelerated beach erosion is reduction of the supply of sand to the shoreline. Most beach sand is generated inland and delivered to the shoreline by coastal streams, a process detailed in the Coastal Land Environment element. This continued supply of sand has been greatly impaired by upstream development activity, most commonly by structures within the stream channel that block the transport of sand (e.g., the annual delivery of sediments to Imperial Beach has now been reduced to 180,000 cubic yards from an estimated volume under previous natural conditions of 660,000 cubic yards).

16. Shoreline Sand Supply. The shoreline sand supply is transported by waves and wave currents in three kinds of movement—offshore, onshore, and longshore. The sand moves laterally along the shore, usually southward; as it is being transported offshore and returned onshore. The sand movement along the shore occurs within sections of the coast, referred to as "littoral cells." These extend from the point where the sand supply is introduced, mostly by streams, downdrift to the place where it is swept out to sea, often into offshore canyons. There sometimes are small indentations in the coast within cells, isolated from the sand movement system of the rest of the cell by rocky headlands. Within these areas, cliff erosion and onshore currents probably supply the sand to small pocket beaches.

17. Man's Impact on Sand Supply. The stability of sand beach depends on maintaining the equilibrium of a sand budget—a balance between supply and removal (the loss of sand to wave action) within a cell or pocket beach area. Man's activity has not only reduced the supply, it has also increased the loss through faulty design of groins, jetties, breakwaters and dredged channel entrances in shoreline waters.

18. Potential Shoreline Erosion Damage. Damage due to beach erosion in California was approximately $10 million in 1965. The Water Resources Council projects the annual loss to be $15.7 million in 1980 and $26.7 million by 2000, unless large-scale preventive measures are taken. These measures may cost over $1 million for a single beach area.

19. Maintaining Sand Supply. Several measures for increasing the sand supply are:

a. Mining offshore submarine fans and canyon heads.

b. Placing harbor dredge material on beaches downdrift from the harbor entrance.

c. Transporting material from behind inland dams and other inland sand sources to depleted beaches by increasing dam release of water and sediment by-pass, or by transportation to the affected beach areas by truck. However, all these processes are extremely expensive.

Among other methods for decreasing sand loss from beaches are:

a. Engineering structures such as riprap, seawalls, groins and detached breakwaters.

b. Engineering devices such as created submerged reefs and perched beaches (coarse sand placed atop an existing beach).

c. Careful design of channel entrances to embayments to maintain equilibrium between entrance size and tidal prism.

20. Erosion of Seacliffs. The breakdown of seacliffs by wave action is a natural and constant process, the rate depending on the resistance of the cliff material, the conformation of the shoreline and the height of the cliff. These processes are extremely complex and should not be tampered with unless irreplaceable coastal resources are threatened.

21. Protection of Seacliffs. The best natural defense of seacliffs against wave action is a fronting beach that is both high and wide. Valuable areas of seacliff lacking natural protection can be preserved by artificial means, which should be carefully engineered to avoid beach erosion or shoaling. These protective measures include (a) mechanical replacement of eroded beach material; (b) construction of a bank of dunes between cliff and waveline planted with native vegetation; and (c) construction of offshore groins or breakwaters to reduce wave energy.

22. Runoff Erosion in the Coastal Zone. Erosion also results from storm runoff, but poses a minor hazard under normal conditions. It becomes a major hazard only when man's activity alters the runoff pattern and accelerates the erosional process, or when severe natural erosion is disregarded.

23. Current Shoreline Protection Studies. The U. S. Army Corps of Engineers and the California Department of Navigation and Ocean Development operate a cooperative program to study shoreline erosion. These studies are almost complete in Southern California and are continuing in Northern areas. These research programs only indicate broad erosion problems, however, and accurate determination of erosion processes requires site-specific analysis before construction proceeds.

24. Public Cost Burden. Development which interferes with natural geologic processes may impose direct or indirect costs on the public.

## Policies

1. Geologic Safety Measures Necessary. Because many areas of the California coastal zone exhibit various geologic instabilities—earth-shaking, landsliding, tsunamis and shoreline erosion—and because the possibilities of damage from geologic hazard along many sections of the coast are great, measures to ensure geologically safe land use within the coastal zone are essential. The local agency seismic safety elements now in preparation should lead to definitive policies for application in land use programs.

2. Safety of Projects Should be Individually Checked. Since adequate information about earthquake and other geologic hazards is inconsistently available for specific sites, the geologic data and resulting engineering proposals for individual projects in the coastal zone should be subject to review and approval to achieve site stability and structural safety.

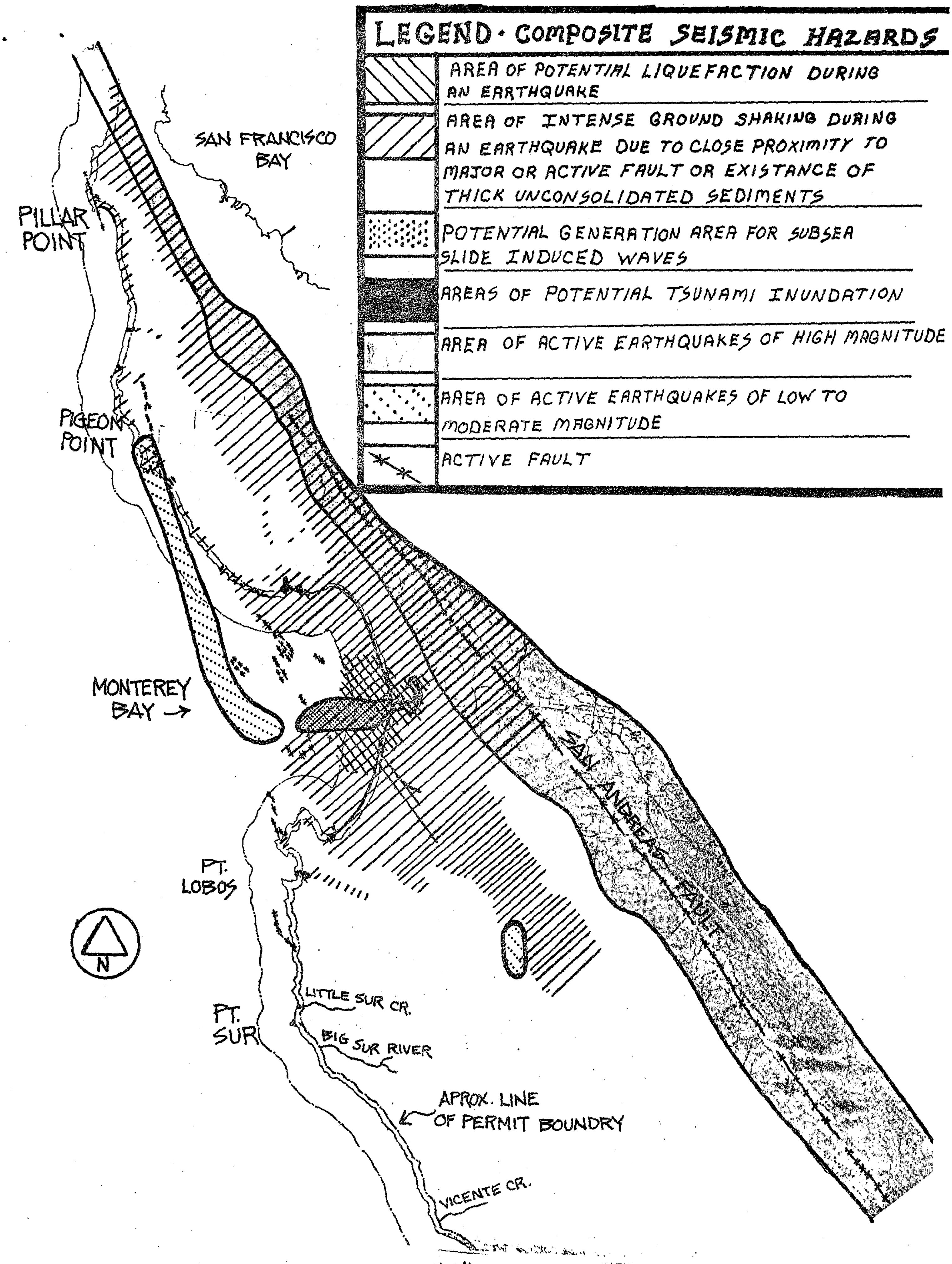

LEGEND · COMPOSITE SEISMIC HAZARDS
AREA OF POTENTIAL LIQUEFACTION DURING AN EARTHQUAKE
AREA OF INTENSE GROUND SHAKING DURING AN EARTHQUAKE DUE TO CLOSE PROXIMITY TO MAJOR OR ACTIVE FAULT OR EXISTANCE OF THICK UNCONSOLIDATED SEDIMENTS
POTENTIAL GENERATION AREA FOR SUBSEA SLIDE INDUCED WAVES
AREAS OF POTENTIAL TSUNAMI INUNDATION
AREA OF ACTIVE EARTHQUAKES OF HIGH MAGNITUDE
AREA OF ACTIVE EARTHQUAKES OF LOW TO MODERATE MAGNITUDE
ACTIVE FAULT
SAN FRANCISCO BAY
PILLAR POINT
PIGEON POINT
MONTEREY BAY
SAN ANDREAS FAULT
PT. LOBOS
N
PT. SUR
LITTLE SUR CR.
BIG SUR RIVER
APROX. LINE OF PERMIT BOUNDRY
VICENTE CR.

FIGURE "A"

3. Statewide Geological Safety Measures Should be Upgraded. In order to achieve uniform compliance of local governments toward geologic hazards, the Coastal Commission endorses the recommendations of the Joint Committee on Seismic Safety, including its proposal to establish a Geologic Hazards Review Board to deal with all geologic risks. The Commission also encourages appropriate revisions of the Uniform Building Code. Because of inadequate and sporadic application of the Uniform Building Code in California's coastal zone, enactment of the code needs to be strengthened by providing funds, personnel, and training for vigorous enforcement. In addition, the Uniform Building Code, 1970 Edition, should be upgraded relative to earthquake shaking forces.

4. Multi-Discipline Advisory Board Needed. Because consideration of the several types of geologic hazard that exist in the coastal zone encompasses a number of geologic and engineering disciplines, adequate project review requires a statewide and six regional interdisciplinary advisory boards having expertise in geology, oceanography, soil engineering, engineering geology, structural engineering, civil engineering and architecture, reflecting in large measure the recommendations of the Joint Legislative Committee on Seismic Safety. This group will review development proposals in the composite seismic hazard area outlined on the attached map. Larger scale maps are available in the Commission office. They will be revised based on local agency's Seismic Safety elements.

5. Interim Development Guidelines for Geologic Hazard Areas. To reduce potential damage from geologic hazards pending recommendations of an interdisciplinary advisory board, no development should be allowed in:

   a. Seismic hazard areas delineated on earthquake fault maps, soils maps indicating materials prone to shaking or liquefaction, and local and county seismic safety plans,

   b. Landslide hazard areas delineated on slope-stability maps, and local and county planning studies,

   c. Ocean bluff and cliff areas, and

   d. Areas specified in Composite Seismic Hazard Map (Figure A).

   unless the proposed construction site has been analyzed by a survey team including a design civil engineer, a soils engineer, and an engineering geologist, all registered in the State of California; and site treatment and building construction techniques adequate to overcome the hazard have been approved by the team.

6. Interim Development Guidelines for Tsunami Runup Areas. To reduce damage from seismic sea waves, no development should be allowed in areas delineated in Figure A and in forthcoming U. S. Army Corps of Engineers 100-year recurrence maps of tsunami runup, and other known areas of tsunami risk, unless it is designed to withstand the force of the waves and can sustain flooding. Under no circumstances should hospitals, schools, emergency public services, or other public buildings be constructed within these tsunami runup areas.

7. Interim Guidelines for Shoreline Protection and Channel Works. To minimize beach erosion, developments such as revetments, breakwaters, groins, harbor channels and other construction should not be allowed unless the Army Corps of Engineers and the California Department of Navigation and Ocean Development certify, on the basis of the best

information available, that the project will not impair the local sand supply of an area or the longshore transport of sand within littoral cells.

8. Interim Coastal Erosion Guidelines.

A. Geology Stability

All developments within the immediate beach-coastal bluff area of the Central Coast Region must demonstrate geologic stability of the structure for a 50-year period, must not contribute to instability of any cliff or beach, and must be consistent with other policies of the Coastal Zone Plan.

The following definitions of coastal stability shall apply to the Central Coastal Region: (See Figures I-M)

High stability areas
(1) less than 1 foot/year historic cliff retreat,
(2) inherently stable cliff material,
and (3) not dependent upon a beach for its stability.

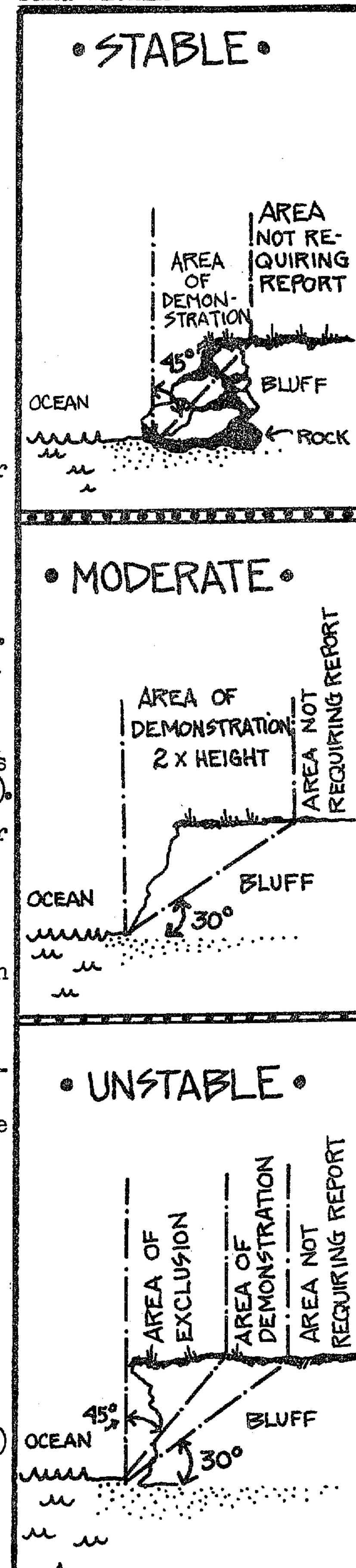
In high stability areas, any development proposed within the area from the toe of the bluff to a point on top of the bluff at a 1:1 ($45^o$) slope from the toe must demonstrate stability as defined above (with a geologic engineering rpt.).

Moderate stability areas
(1) less than 1 foot/year historic cliff retreat,
(2) inherently unstable cliff material,
and (3) may be dependent upon a fronting beach for stability.

In moderate stability areas, any proposed development within the area of 2:1 ($30^o$) slope from the toe to the top of the bluff must demonstrate stability as defined above.

Low stability areas
(1) greater than 1 foot/year historic cliff retreat,
or (2) landslides or other inherently unstable material (such as beach sand or active dunes).

In low stability areas, any proposed development must be excluded from the area of 1:1 ($45^o$) slope from toe to top of bluff, and from the area of active movement, and stability must be demonstrated for a 50 year economic life within the remaining area of 2:1 ($30^o$) slope.



Areas currently considered to be stable, moderately stable, and unstable are indicated on the accompanying maps. Designation of these areas may change as additional technical information becomes available. The geologic engineering report to be reviewed by the Geologic Hazard Advisory Board should include:

an evaluation of the base erosion

the geometry of the cliff

the geologic conditions

the characteristics of the soil and rock materials

the various forces acting on the cliffs

B. Shoreline Protection

All development within the coastal erosion zone shall be planned so as not to require future shoreline protection measures.

Since developments currently exist in unstable geologic areas and areas of active coastal erosion, and individual instances of cliff fall-off or beach loss must be anticipated, shoreline protection measures must have a direct relationship to the protection of existing development and the hazard must be demonstrated.

Shoreline protection measures shall not contribute to instability of any cliff, beach or coastal frontage.

Since shoreline protection devices have impacts beyond erosion control, proposed seawalls and other devices will also require particular conformance to policies on appearance and design, access to beaches and the high tide line, and other pertinent policies.

9. Available Geologic Information Should Be Fully Utilized. To reduce loss of life and property damage from geological processes as quickly as possible, the large amount of pertinent data on geologic hazards being assembled by such agencies at the California Division of Mines and Geology, the U. S. Geological Survey, the National Ocean Survey, the U. S. Army Corps of Engineers, the Seismological Laboratory of California Institute of Technology, tec., should be fully utilized in all land use planning and development evaluations. The accelerated accumulation of necessary geologic data should be encouraged.

10. Public Should Not Be Liable. In areas where geologic hazards recur or are identified and development proceeds with knowledge of these but without the appropriate precautions, there should be no presumption of public liability for property loss (disaster loans, or forms of insurance borne by the general public, etc.).

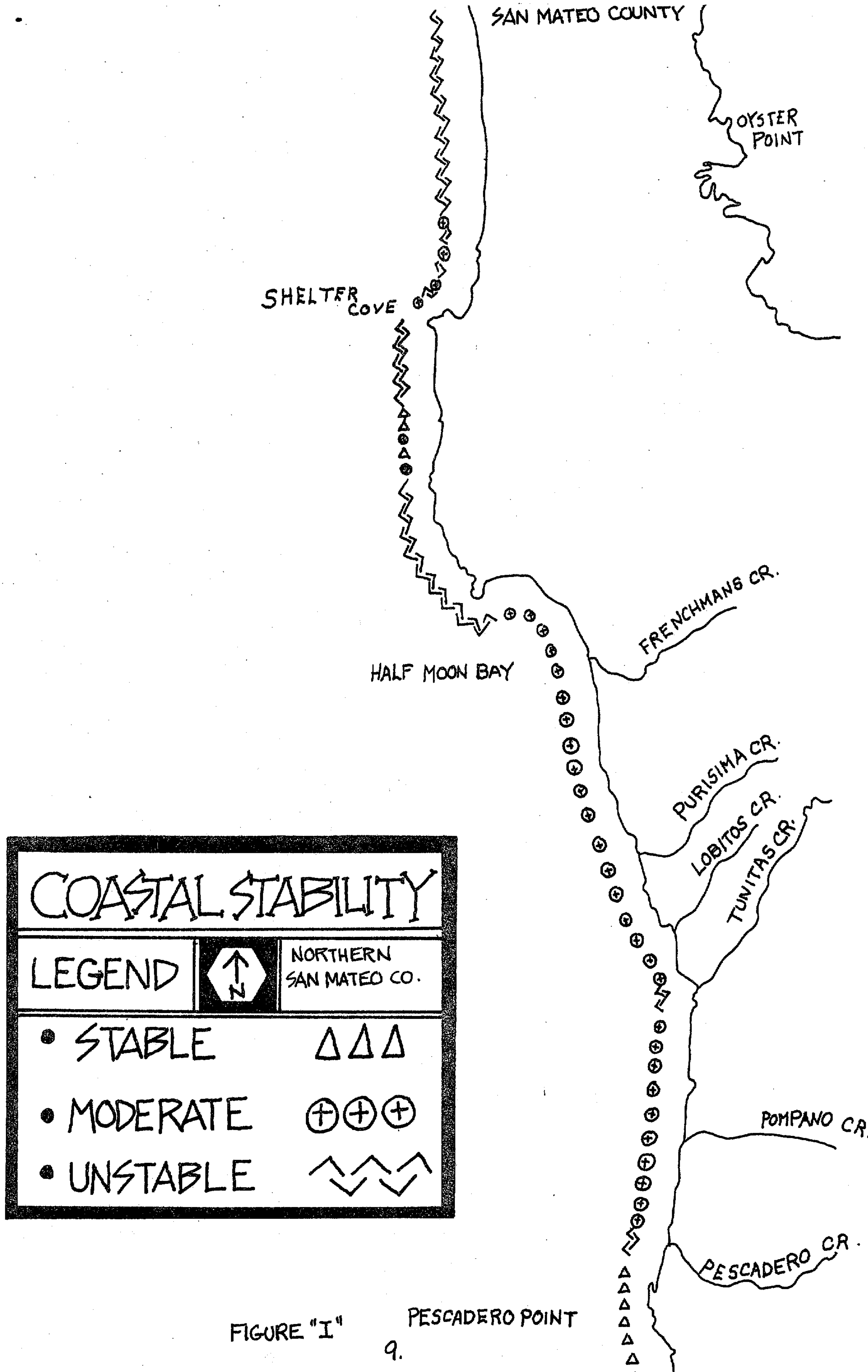
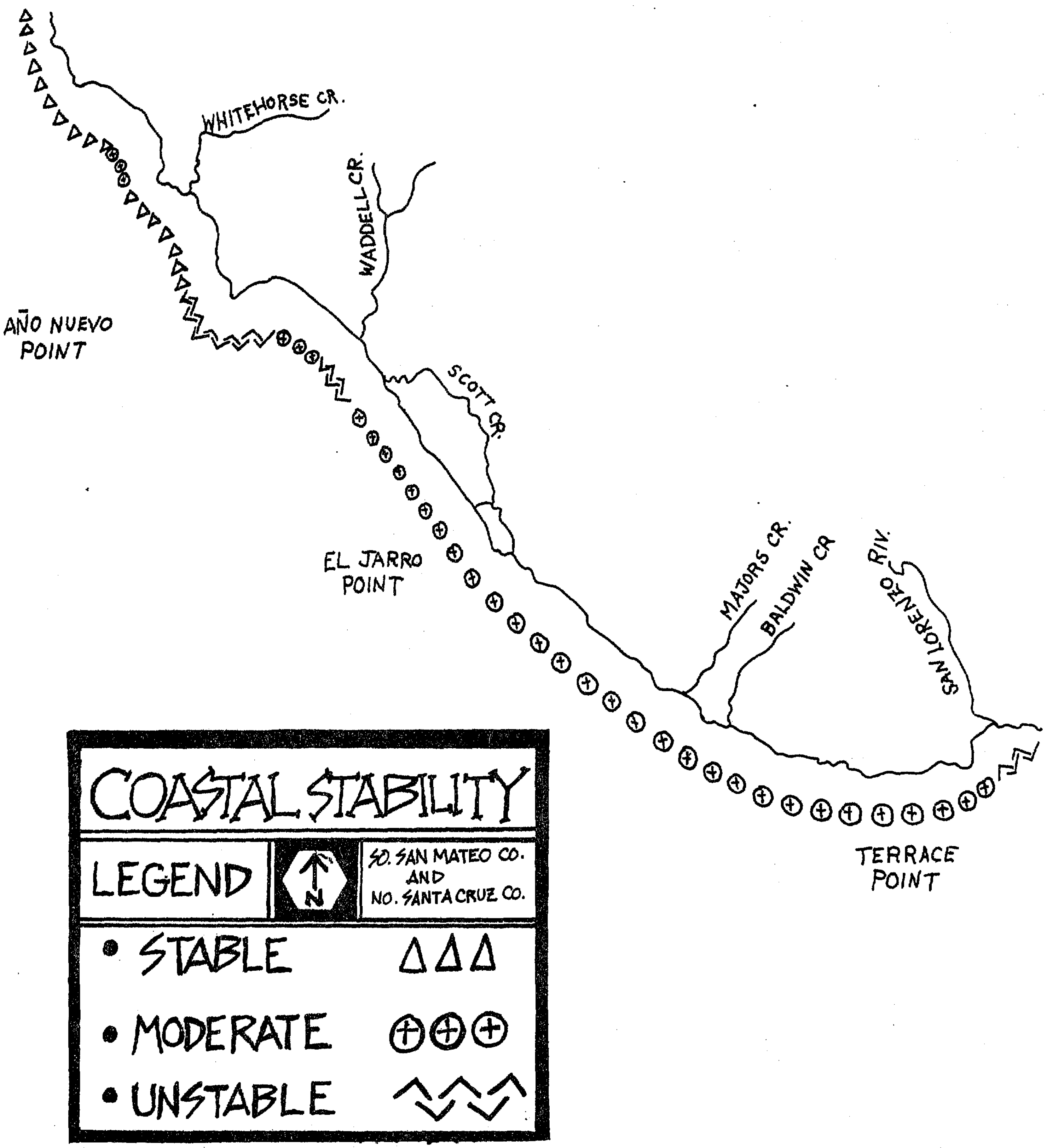

SAN MATEO COUNTY
OYSTER POINT
SHELTER COVE
HALF MOON BAY
FRENCHMANS CR.
PURISIMA CR.
LOBITOS CR.
TUNITAS CR.
POMPANO CR.
PESCADERO CR.
PESCADERO POINT
COASTAL STABILITY
LEGEND
N
NORTHERN SAN MATEO CO.
STABLE
MODERATE
UNSTABLE

FIGURE "I"



WHITEHORSE CR.
WADDELL CR.
AÑO NUEVO POINT
SCOTT CR.
EL JARRO POINT
MAJORS CR.
BALDWIN CR
SAN LORENZO RIV.
TERRACE POINT
COASTAL STABILITY
LEGEND
N
SO. SAN MATEO CO. AND NO. SANTA CRUZ CO.
• STABLE
• MODERATE
• UNSTABLE


FIGURE "J"

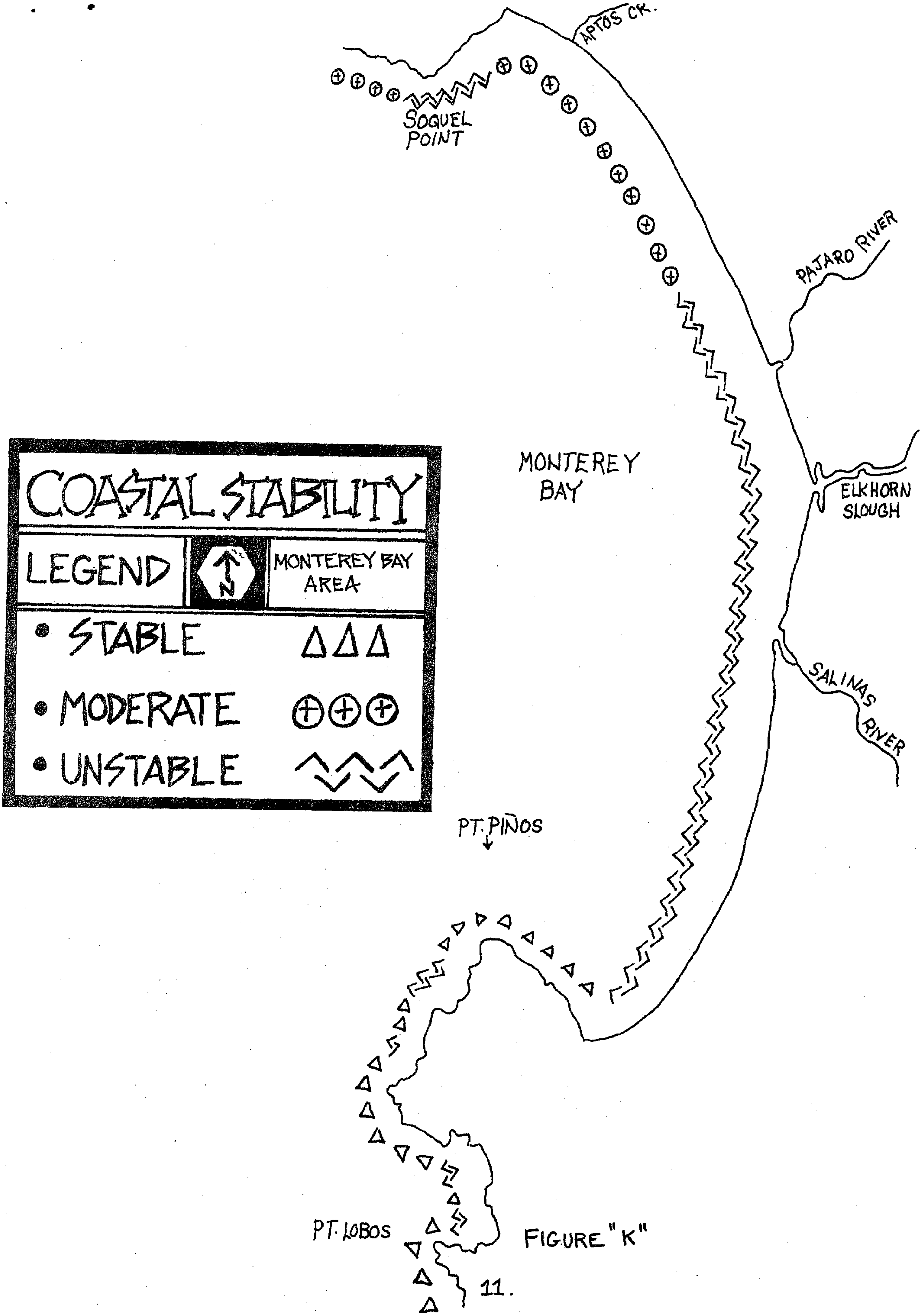

COASTAL STABILITY
LEGEND
N
MONTEREY BAY AREA
STABLE
MODERATE
UNSTABLE
APTOS CK.
SOQUEL POINT
PAJARO RIVER
MONTEREY BAY
ELKHORN SLOUGH
SALINAS RIVER
PT. PIÑOS
PT. LOBOS

FIGURE "K"

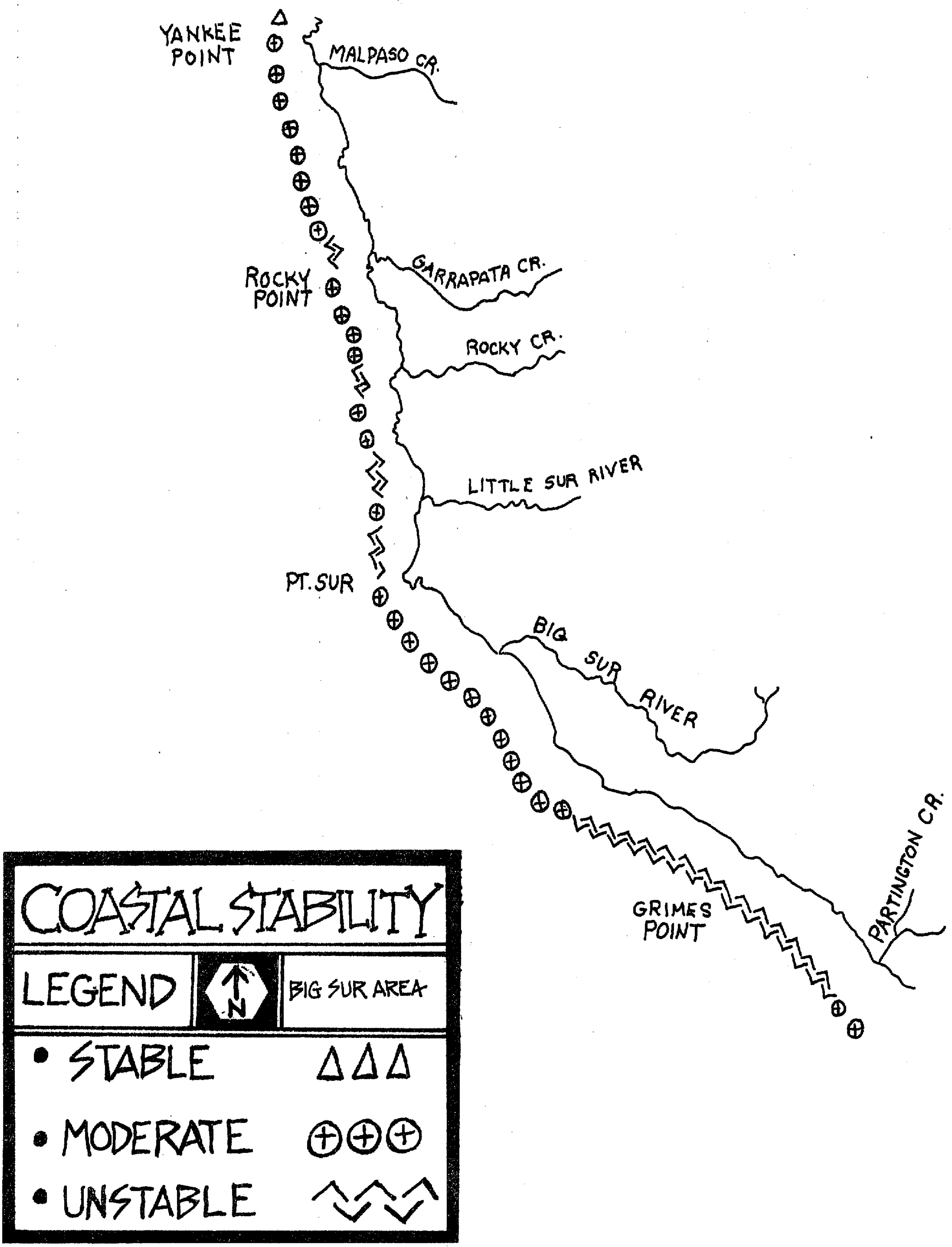

YANKEE POINT
MALPASO CR.
GARRAPATA CR.
ROCKY POINT
ROCKY CR.
LITTLE SUR RIVER
PT. SUR
BIG SUR RIVER
PARTINGTON CR.
GRIMES POINT
COASTAL STABILITY
LEGEND
N
BIG SUR AREA
• STABLE
• MODERATE
• UNSTABLE

FIGURE "L"

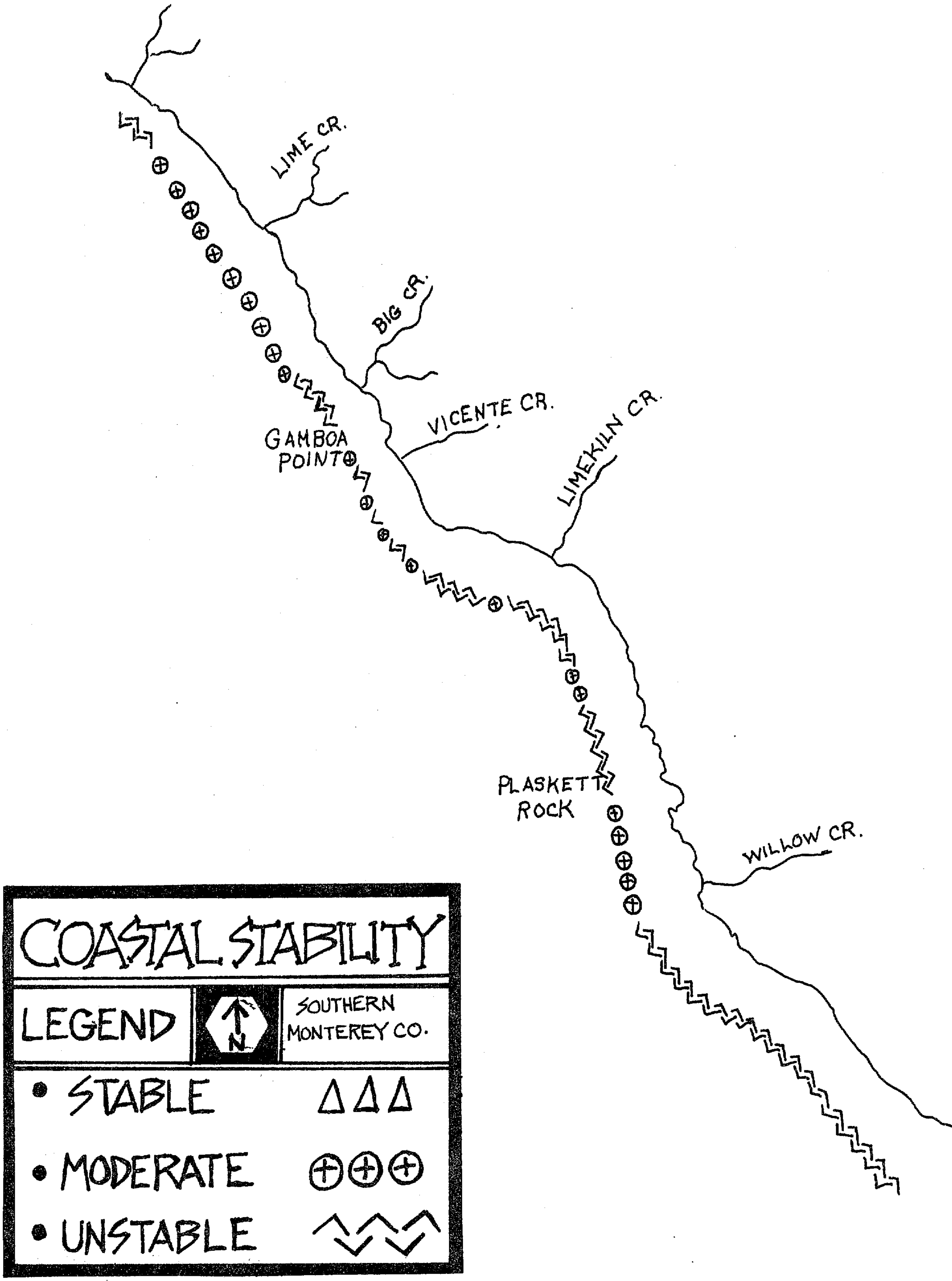

LIME CR.
BIG CR.
VICENTE CR.
LIMEKILN CR.
GAMBOA POINT
PLASKETT ROCK
WILLOW CR.
COASTAL STABILITY
LEGEND
N
SOUTHERN MONTEREY CO.
• STABLE
• MODERATE
• UNSTABLE

*FIGURE "M"

STATE OF CALIFORNIA RONALD REAGAN, Governor

CALIFORNIA COASTAL ZONE CONSERVATION COMMISSION
CENTRAL COAST REGIONAL COMMISSION
701 OCEAN STREET, ROOM 300
SANTA CRUZ, CALIFORNIA 95060
PHONE: (408) 426-7390

April 8, 1974

Please find enclosed a copy of the summary report "Geology." We especially direct your attention to the proposed findings and policies. They are based on an extensive technical report which is available in our office and at the libraries listed in the preface.

The Central Coast Regional Commission is committed to maximizing public input into our planning process. To facilitate your contribution to this effort, we have scheduled the following public discussion meetings:

Friday, April 19, 1974
Monterey Peninsula College
Social Science 102
Monterey County
7:30 p.m.

Friday, April 26, 1974
Skyline College
Building 2, Room 308
San Mateo County
7:30 p.m.

Monday, May 6, 1974
Board of Supervisors Chambers
Santa Cruz County
(Time to be announced)
(Formal Public Hearing)

Any person or organization can make a statement at these meetings. Written comments received before May 1, 1974, will be incorporated into the revised findings and policies for Commission action in May.

If you have any questions regarding this procedure or the report's contents, please call Don Neuwirth, on our staff at (408) 426-7390. We are sure you realize the importance of the coastal planning effort in complying with the voter's mandate of Proposition 20, and appreciate your time and effort in reviewing this document.

Thank you very much.

Sincerely,

Edward Y. Brown

Edward Y. Brown
Executive Director

EYB:pas

Enclosures